THE

PHYSICAL ATLAS

OF

NATURAL PHÆNOMENA

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BOMBAY BRANCH
OF THE
ROYAL ASIATIC SOCIETY.
TOWN HALL, BOMBAY.

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OF
NATURAL PHENOMENA

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BY

ALEXANDER KEITH JOHNSTON

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A New and Enlarged Edition

WILLIAM BLACKWOOD AND SONS
EDINBURGH AND LONDON
MDCCCLVI

PREFACE TO THE SECOND EDITION.

The object originally contemplated in this Work was to present, in a graphic form, a concise yet comprehensive view of the Physical Geography of the Globe, embracing under that term its superficial structure, the movements of its aerial and oceanic currents, and the distribution of organised existence on its surface. The importance and utility of this interesting branch of knowledge, and the absence in this country of the necessary aids for its study, induced the Author to undertake the production of a series of Maps and other illustrations of Natural Phenomena, considered in their mutual relations and dependencies, on a scale worthy of the subject, and which, with descriptive letterpress, might be in accordance with the development of other branches of science. After five years of unremitting labour and research, the Physical Atlas of Natural Phenomena, consisting of thirty plates and ninety-two folio pages of text, appeared in April 1848.

The first impression having been exhausted, and a new edition called for, the Author availed himself of the opportunity to extend the domain of Physical Geography, by the introduction of some subjects not hitherto embraced in that comprehensive term, but which, he conceived, would complete his design, and so enhance the value of the Atlas as to render it more worthy of the flattering reception it has met with. This Edition contains seven Maps, each accompanied by an Original Essay, comprising together twenty-eight pages of letterpress, on themes not contemplated in the First Edition; viz. the Distribution of Marine Life, the Geology of Europe and of the United States and British North America, the Physical Characteristics of the Arctic Polar Basin, Terrestrial Magnetism, the Moral and Statistical Classification of the Human Family, and the Geographical Distribution of Health and Disease. Six Maps, comprising Botanical Geography, Isothermal Lines, Currents of Air, and the Mountain Systems of Europe, Asia, and America, designed in the German manner by Professor Berghaus of Berlin, have been withdrawn, and in their place new Maps, constructed from fresh Materials, in a style similar to the rest of the Work, have been substituted. The letterpress explanatory of these Plates has been rewritten, and extended from eighteen to twenty-two pages, and six smaller Plate-illustrations have been inserted in the Text.

The twenty-three Maps which are retained have been thoroughly revised, and in many cases considerably altered and enlarged; while of the remaining seventy-four pages of letterpress, fourteen have been rewritten, and the others corrected and enlarged where requisite. There are thus twenty Plate-illustrations and sixty-four pages of letterpress in this which did not appear in the First Edition; and a carefully compiled Index has been appended, an inspection of which will at once show the vast field of human knowledge embraced in the Work.

The Author begs to express his obligations to the Baron Alexander von Humboldt, at whose suggestion the Work was undertaken, and to those eminent scholars and philosophers who have enriched the volume by the valuable contributions to which their names are appended; and in concluding his arduous and interesting labours, he ventures to indulge the hope that the Physical Atlas may now, in its extended form, be still more worthy of taking its place as a Work of standard reference and authority.

A. KEITH JOHNSTON.

Edinburgh, *June* 1856.

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THE

PHYSICAL ATLAS.

NOTES ON SOME GENERAL PRINCIPLES IN GEOLOGY; AND THEIR APPLICATIONS.

BY

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A

EXPLANATIONS RELATING TO THE CONSTRUCTION OF A GEOLOGICAL MAP OF THE GLOBE.

(CHIEFLY ABSTRACTED FROM M. BOUÉ'S MEMOIR IN THE "BULLETIN DE LA SOCIETE GEOLOGIQUE DE FRANCE." TOM. PREMIER, DEUXIÈME SERIE.)

THE attempt to construct a Geological Map of the entire Globe would rightly be deemed a chimerical undertaking, if the author of it depended solely on observation of details, or if he should pretend that his results are endowed with an absolute accuracy. But actual geological observation already points towards many of those general principles that enable a sound Thinker to invade the unknown, on the ground of *Analogy*;—a task perilous at the best, and to be undertaken by no one without a due sense of his many hazards of error. The venture, however, was made, a good many years ago, by M. Boué; and with singular success. Since our first publication of his revised map, positive light has been thrown on the constitution of large regions of both hemispheres; and a comparison of that map with the one now presented to the public—enriched by the discoveries of Sir R. MURCHISON, and of our INDIAN and AUSTRALIAN, as well as of indefatigable AMERICAN Explorers—with the one in our original edition, must obtain for what is still conjectural in this most important chart, a full title to be accepted as a trustworthy *pioneer*.

I.

Considering the greatness of his enterprise, and the imperfection of our knowledge of the details of the geological structure of the globe, BOUÉ very wisely restricted himself to an attempt to trace the distribution and arrangement of SIX GRAND FORMATIONS or groups of rocks, each formation—of course—including a long series of products and changes, connected for the most part by natural relations. The six groups are these:—

I. THE CRYSTALLINE SCHISTOUS FORMATION, COMPREHENDING ALL THE GRANITOID ROCKS.
II. THE PRIMARY STRATIFICATIONS, OR THE TRANSITION SERIES, INCLUDING THE CARBONIFEROUS FORMATION.
III. THE SECONDARY FORMATION, EXTENDING FROM THE CLOSE OF THE CARBONIFEROUS SERIES TO THE CLOSE OF THE CRETACEOUS.
IV. THE TERTIARY FORMATION.
V. THE ALLUVIUM, OR MODERN DETRITUS.
VI. VOLCANOES: IGNEOUS ROCKS OF THE TERTIARY AND ALLUVIAL EPOCHS; AND SOME EXTRA-EUROPEAN PORPHYRIES AND DIORITES.

The colours indicating these different groups are explained on the map.

II.

In the essay accompanying his work, as well as in the "*Guide du Geologue Voyageur*," BOUÉ gives a list of his authorities as to the distribution of these six groups; and it is only doing him justice to say, that his list, even now, forms our most complete bibliography of geological literature. But these positive materials, however ample, and augmented by all that has been accumulated since, are far from sufficient to entitle any one to construct a Geological Map of the Globe, on the ground of a mere arrangement of separate established facts. If every district, hitherto actually examined, were coloured on a map of the world, the surfaces, thus distinguished, would appear very unimportant in magnitude compared with those others exhibiting the absence of all knowledge derived from personal and approved inspection. Fortunately, however, the parts of the globe whose constitution has been laid bare by actual scrutiny, manifest unequivocal marks of the prevalence of Order and System, in the arrangement of the various formations; and although the relations, thus indicated, are not yet, in all respects, perfectly defined, nor the irregularities or apparently exceptional cases, connected with them, sufficiently known, they still justify us in drawing inferences from single facts, that are often *highly probable*. A map constructed, in a great measure, in reliance on laws and relations which are not absolutely established, cannot indeed pretend to minute accuracy: but instead of being therefore disregarded as the result of an ambitious fancy, or a mass of mere barren conjectures, it must—in so far as it conscientiously presents the sum of our positive knowledge, and rests its deductions on the most general of the laws hitherto recognised—be received as one of those important and vigorous *reconnaissances*, which are often preludes of solid discovery.

The facts from which the Geological Structure of an unexplored country may be deduced, are manifestly those of PHYSICAL GEOGRAPHY. This branch of knowledge is merely a description of the forms into which great Revolutions have cast the present surface of the Earth; and as these forms must be supposed to indicate the nature of their *efficient* causes, similarity in the contour of distant portions of the Earth's surface should thus, in so far, indicate similarity in geognostical constitution. The expected analogy, indeed, often extends even to extremely minute features. Comparing, for instance, the central spine of Asia, from the Taurus and Caucasus to the Pacific, with the Alpine masses of Europe, it is not difficult to perceive a most striking correspondence among all their dependencies. In each of the two continents, lying between enormous hollows now filled by seas, we find a large central mass or nucleus, composed of schistous and granitic rocks, bifurcated at its extremities, where it exhibits transition and secondary formations, also found to the north. If Asia Minor in so far corresponds with the Pyrenees and the ancient and partly igneous islet of central France, the Hungarian and Styrian basins between the divisions of the Alps are repeated in China on a very large scale; whilst the basin of the lower Danube corresponds with that of Tonquin, other districts of Turkey in Europe are virtually reproduced in the peninsula beyond the Ganges. On the shoulders of the Central Asiatic mass, we find the same secondary chains as in the Alps; and in both continents, tertiary deposits fill up isolated basins among mountains that appear as low heights, between the secondary zone and the tertiary and alluvial plain. Regarded from the same point of view, the deserts of Turkestan and Mongolia are only a repetition of the great tertiary and alluvial low land to the north of the Alps; the immense valleys of the Ganges and lower Indus recall those of Piedmont and Venetian Lombardy; whilst the basins of the higher Euphrates, of Cabool, Cashmere, Ladak, Lassa, &c., have counterparts in the isolated tertiary cavities of Belluna, Carinthia, of the upper Muhr, the upper Inn, &c. Nor does the likeness stop even here; for, while the calcareous Alps of Asia enclose isolated tertiary basins like those of Europe, they exhibit also, in places precisely similar, clefts or passages opened by nature, which have in both instances been the arteries of commerce, and the defiles whose possession has always ranked so important in war; and in localities exactly corresponding we have the seats of civilization and power. It is scarcely needful to refer to the enclosed basins of Persia, Tibet, Cashmere, &c.: the *cols* of the Hindoo Koosh offer similitudes to the well-known *cols* of the Swiss Alps;—"Delhi," says Boué, "is Milan, Calcutta reminds us of Venice, while Bombay is the counterpart of Genoa."—Passing from these great central masses themselves, to their environs, we are likewise everywhere met by close and unlooked-for analogies. North of the Asiatic protuberance—beyond the cavity of the desert—the Altai presents a crystalline and transition region resembling what is found in Europe north of the tertiary depression bordering the Alps; and in Asia, as in our own more neighbouring region, secondary and alluvial deposits divide the districts now referred to, from the older formations which constitute the northerly portion of both continents. So also in the south, Spain seems the analogon of Arabia; Corsica, Sardinia, and Italy, of Hindostan; and Greece and Turkey, of the peninsula beyond the Ganges. That these resemblances are not fanciful, a glance at the map will readily manifest; nay, with due allowance for the effect of local and particular accidents, the analogy might be traced much farther—to the identification, for instance, of the chain Soliman—the prolongation of the Bolor—with the Maritime Alps; and even to the position of those immense hollows which, in both continents, are filled with water. Descending to still smaller minutiæ, it is not easy to escape being struck by the singularly corresponding distribution of the more strictly igneous or volcanic rocks. Is not the great basaltic district of Hindostan a manifest counterpart of the extensive eruptions of serpentine and trachyte in Italy and Turkey; while the volcanoes and their deposits, in the Mediterranean and its Archipelago, and those of Hungary and Asia Minor, have similitudes in Cutch, the Sunda Isles, the Malayan Archipelago, Japan, and Kamtchatka? North of the Alps we find only a few knolls or domes of igneous rocks of this family,—now this accident seems exactly repeated in Asia in the lakes of borate of soda (*e. g.*, that of Tinkal in Tibet); while, at a greater distance from the central chains, the ancient volcanic districts of the Eifel, the banks of the Rhine, the north-west of Germany, and northern Bohemia, seem represented by elevated groups, such as the Caucasus, Ararat, and Demavend, the trachytes between the Caspian and Lake Aral, and the volcanic zone around Lake Baikal.

This remarkable conformity of feature through two immense regions—a conformity as striking as the dissimilarity between the structure of either, and the physical geography and geology of Africa and America—seems to establish, or at least to endow with much probability, what Boué claims as the fundamental idea of speculative geology, viz., that a critical similarity of outward form, while indicating similarity in efficient causes, must also, to a large extent, indicate identity of structure: but this conception being by itself too indefinite for the purposes of a determinate enterprise, our inquirer deemed it necessary to enumerate specifically all those separate external features, from which specific and substantive inferences as to the geognosy of a district may be drawn; and his sagacity and rare ingenuity have enabled him to collect, methodise, and appreciate the whole of those important considerations, which, in the present state of our knowledge, can yield hints regarding the structure of an unexplored region. The results be arrived at are presented—with slight modifications as to arrangement, but very greatly abbreviated—in next section.

III.

I. Indications of the geological structure of a region, derivable from the specialties of its Orography.

1. *From any complete section, either of a mountain chain, or across a continent, the structure of the prolongation of that chain or continent, may generally be safely inferred.*

Since the convulsions or changes, that interrupt or *cut through* mountain chains and continents, are, for the most part, *posterior* in date to the formation of these chains or continents, the series of rocks of which they are composed may generally be expected to stretch across the interruption. For instance, almost all the straits and channels of the ocean are, like the beds of rivers, only clefts, or cavities of erosion; on which account we usually recognise on both sides the same strata. Thus, in the north-west of Ireland and the Orkneys, we find the formations of the Highlands of Scotland; the north-east of Sicily corresponds with southern Calabria; Corsica is prolonged into Sardinia; the same rocks form the two shores of the English Channel, as they do those of the Red Sea, and the opposite sides of the Strait of Gibraltar; the formations of Turkey in Europe must pass in the same manner into Asia Minor; those of the Crimea into the Caucasus; those of Eastern Persia into Beloochistan; and those of Cuba into Jamaica. Thus also, the Strait of Behring separates similar ancient beds; and that of Bab-el-Mandeb is a mere volcanic rift, which has torn the principal chain of Central Africa from the old crest of Southern Arabia. The greater number of our large islands are connected in the same manner, and for the same reason, with continents. For instance, the transition and schistous rocks of Norway, are prolonged, under the sea, to Spitzbergen; the formations of the Oural Mountains stretch towards Novaia Zemlia: the transition series of Russia is found in the Baltic, in Dagoe, and Oesel; and the recent secondary rocks of Eastern Spain reappear in the Balearic Islands. Similar relations exist between the ancient chain of Olympus and Pelion, and part of the islands of the Greek Archipelago; between the secondary system of the Peloponnesus, and the Isle of Crete; between the coasts of Asia Minor, and Cyprus, Rhodes and its other littoral isles, &c. &c. Much light might thus be obtained regarding the *configuration* of considerable portions of the *bottom of the ocean*, as well as with respect to their geological structure—a study as interesting and important in reference to the geodesy of the globe, as the careful measurement of its whole accessible surface; but in the present imperfect state of our knowledge, an attempt at definite delineation were in this case hardly justifiable.[1]

2. *The correspondence of mountain chains, as to* DIRECTION, *evinces similitude in geological constitution.*

This most important fact in the structure of the Earth, presents itself under two aspects.—

A. When the chains are parallel.

The law, in this case, is a corollary from an ingenious theory of the Elevation of mountains (see parts B and C of this disquisition); but altogether independently of theory, it is a certain geological truth, that generally the same structure may be predicated of parallel chains, separated by arms of the sea, straits, or valleys, by igneous deposits, secondary or tertiary basins. Take, as examples, the farther Hebrides, and the north of Scotland; Cornwall, Brittany, and the north-west of Spain; Sweden, and Finland; Marocco, and the south of Spain; California and adjacent America; the Peninsula of Malacca, and Sumatra, &c. &c. But if the proposition is thus true in all countries which have been examined geologically, we may trust to it in the case of districts still unexplored, and receive what it enables us to predict. When, however, chains are not well known geographically, we may fall into error, through mistakes with regard to their *exact direction*.[2]

B. When the chains have identity of direction, although not parallel.

On account of the sphericity of the Earth, ranges of mountains distant from each other will not—although they stand in the same relation to the north or south points—be *parallel*: that they correspond in geological structure, nevertheless, the phenomena of the following characteristic groups prove:—

a. Direction, W. to E. nearly. Many remarkable chains belonging to this group are clearly identical in geological constitution, viz., the principal chain of the Alps; chain south of Transylvania; the Balkan; Taurus; Paropamisus; Hindoo Koosh; Kuenlun; Himalaya; Celestial Mountains, &c. &c.

b. Direction, N. to S. nearly. Distant chains, stretching from north to south, also exhibit an identity of ancient and transition formations, of igneous deposits, of metalliferous veins, and, in most cases, of certain dependent secondary strata, viz.: Certain crests in the north of England; part of the Norwegian Mountains; the banks of the Middle Rhine; Central France; Corsica; the Oural; the chain of Kuznetsk or Western Altai; the chain of Soliman, &c. &c.

c. Direction, N.E., S.W. nearly. Striking geological resemblances here again meet us, notwithstanding the distance between the corresponding ridges. As examples, we have the mountains of Ireland and Scotland, of part of Scandinavia and Finland; chains on the banks of the Lower Rhine; in Saxony; Bohemia; the south of Spain, and very many others. The whole of this group is characterised by the same ancient schistous rocks, the same transition formations, the same porphyritic or dioritic masses, and the same description of metalliferous veins.

d. Direction, N.W. to S.E. nearly. Lying in this direction are the following mountains, widely scattered over the earth, but closely corresponding in their upper, secondary, and tertiary deposits—their peculiar igneous and metamorphic rocks: parts of the north-west of Germany, and of the Apennines; the lower parts of the Spanish Pyrenees; western chains of the Greek Peninsula; Eastern Carpathians; chains of Crimea and Caucasus; ridges bordering the valley of the Red Sea, or rather its granitoid and schistous banks; part of the mountains of Syria; a chain between Mesopotamia and Persia; chains west of Herat; others in Tartaria; the Western Himalaya; Karakorum and Katschi; mountains in Cutch, ridges in Mexico, Guatemala, and Cuba.

e. Direction, N.N.W., E.S.E. nearly. This fifth group, composed of crystalline schists and massive crystalline rocks, comprises the Riesengebirge; Rhodope; Central Pyrenees; the Ballons of Vosges; mountains in Brittany, Western Alleghanies; ridges in Canada, south of the Great Lakes, &c. &c.

f. Direction, E.N.E., W.S.W. nearly. The chain of Vindhya in the north of Hindostan; certain chains at the southern extremity of Africa; some in Spain; and also the Hundsrück,—present, along with uniformity of direction, a corresponding structure, chiefly of transition rocks.

g. Direction, N.N.E., S.S.W. nearly. This more numerous group consists of part of the mountains of Northern Norway; the Western Alps; Western Carpathians; chain between Transylvania and Hungary; certain chains in Spain; ridges of South Calabria and in Sicily; the high Atlas of Marocco; certain chains in the Andes of New Grenada; coast chains in Brazil; chains in Chinese Daouria and Mantchouria. All these exhibit the cretaceous formation, upheaved on crystalline schists and granitoid rocks: in some places even the tertiary soil is disturbed.

h. Direction, N.N.W., S.S.E. nearly. This group is composed of similar very ancient rocks, and includes the two great chains of Arctic America and their parallel dependencies; part of the Andes, and of the Cordilleras of Western Brazil; the Western Ghauts; chains in the Peninsula beyond the Ganges; the Bolor, &c. &c.

M. Boué has given extended lists under each of these groups, and he might have added many more; but enough is adduced to exhibit the existence and illustrate the character of an apparently primal law amongst the revolutions of the Earth; and to enable the geologist to venture, in comparative security, opinions concerning the structure of countries that have not been individually explored.

3. *Inferences from the different* HEIGHTS *of Mountain Chains.*

When a lofty ridge is flanked by parallel chains much lower than itself, as well as by plains, we shall generally find that it consists of an ancient central mass, with associated secondary and tertiary formations. Thus, owing to the similarity of the physical aspects of the Alps and those of the mountains of Central Asia, we are enabled to presume that the latter—like the former—exhibit central chains of crystalline schist without transition rocks, with lateral chains of recent secondary masses; then small hills of molasse or tertiary rocks separating these from the plains, or the basins of great rivers; and finally, of isolated tertiary basins watered by streams. Now, this is exactly the arrangement of the masses in question; and the discovery has astonished those who give no credit to geological predictions, and who have never observed the majestic harmony of the geographical distribution of the different formations over the globe. Other striking examples may be found connecting the physical and geological geography of Syria, Mesopotamia, Persia, and Arabia; and also very abundantly in the two Americas.

4. *Indications afforded by the general aspect of mountains, or of their* ESCARPMENTS.

This feature of mountain chains forcibly attracts the notice of the traveller who has an eye to the picturesque; and valuable geological inferences may frequently be drawn from his descriptive sketches. Thus, blunt cones with craters indicate volcanoes; a series of peaks like a saw, denotes dolomites; rounded heads like the tops of nails, characterise calcareous rocks; triangular points, slates or quartziferous schists; needles, crystalline schists; capricious twistings and crumplings, serpentines and trachytes; pyramidal forms, phonolites, &c. &c.: thin and dark-looking walls intimate the presence of basalts, trachytes or traps, as on certain coasts of Greenland, some of the Arctic islands, and the north-west of Australia. Rocks broken up by the weather into roundish masses are granites or grits, or, more rarely, traps. Many other suggestive details might be deduced from the natural configuration of rocks.

II. General Geological principles connected with the Hydrography of a Country.

1. *The phenomena of* RIVERS *are highly instructive in theoretical Geology, although they do not yield very definite laws. Their chief bearings and importance are as follows:—*

a. The different Formations present striking contrasts as to their POTAMOGRAPHY, mainly owing to the very different proportion of surface, occupied by their valleys. The river courses of the crystalline schistous soil are characterised by their great extent—the number of their bifurcations and of their undulations; such, for instance, are those courses among the central Alps, in Brittany, in Brazil, among the chains between China, Tonquin, and Cochin-China. In calcareous soils such courses are less frequent and less undulating; many of the valleys are dry, or have waters which soon lose themselves—rivers even being engulfed beneath their cliffs. The potamography of Western Arabia denotes, of itself, the prevalence of a calcareous structure. The hydrography of the tertiary basins likewise differs much from that of the chalk, of the jurassic formations, or of the secondary sandstones.

b. Great Rivers have, for the most part, at their *mouths*, extensive *deltas* of *alluvium*—deltas usually traversed by several of their branches; so that, from our knowledge of the nature of the deltas of the grand rivers of Europe, as well as of several others belonging to other continents, such as the Nile, the Senegal, the Niger, the Euphrates, the Indus, the Ganges, the Volga, the Lena, the Yenesei, the Obi, the Mackenzie, Mississippi, Oyapok, and the La Plata—we may conclude with equal certainty that similar alluviums characterise districts at the mouths of the Amour, the Sir, the Kistna, the Godavery, &c., as well as the Amazon, the Orinoco, the Rio del Norte, &c., in America. There are, however, distinctions in regard to these deltas. Rivers that escape suddenly from an escarpment of rocks bounding the sea-shore, have no deltas, properly so called, but carry their alluvium on into the sea, and deposit it beyond the line of the shore. Such, for instance, is the case with most of the American streams flowing into the Pacific (high mountains bounding its coasts in almost every part), while the contrary holds with those which flow from the same continent into the Atlantic Ocean.

c. As tertiary deposits also accompany the *courses* or beds of all great rivers behind whose deltas or embouchures considerable plains or extensive valleys are situated, we may infer that such deposits exist in many districts hitherto surveyed only by the geographer. Thus, with little risk of error, we may map down the locality of tertiary formations in Africa, along the Senegal, the Gambia, the Orange River, the Zambeze, &c.; in Asia, on the Kizil Irmak, the Kur, the Euphrates, the Amour, the Sir, the Indus, the Ganges, the Bramapoutra, the Irrawady, the Menam, the Cambodia, the Sang Koi, the Blue and Yellow Rivers, in China, and at least on the Obi in Siberia. The fact, indeed, is already beyond doubt with regard to the more important streams. But analogy entitles us to go still farther. The great alluvial and tertiary plains of the lower Danube, of the Pampas, and the lower Mississippi, have their distinct analogons on the banks of the Amazon, of the lower Ganges, and in the country between Pekin and the Yellow River; and from the nature of the deposits in the first-named localities, the fossils which characterize them, and the mode of their formation, we are induced to infer similar facts in regard to the kindred beds in those other countries which are much less known.

d. It seems probable, *a priori*, that all tertiary basins on the shore, especially such as have no barrier toward the sea, include *marine formations*, or lagunes of salt water, rather than deposits resulting solely from fresh water; whilst the contrary is probable in the case with such basins far inland; and one may predict, with considerable certainty, where these salt-water deposits will be found, and where the detritus of ancient inland seas or great lakes. Thus it will one day be discovered that the African Sahara, with its salt deposits, is the bottom of an ancient Mediterranean Sea; and that the other tertiary deposits on the shores of that continent are marine. The desert north of the chain of Kuenlun, and that of Gobi, are, on the contrary, for the most part fresh-water formations, &c. &c.—The basins of almost all plains which are elevated, or remote from the sea, are tertiary deposits of fresh-water origin; but, previous to drawing this inference as to any unexamined basin, it is necessary that one examine with care the levels of the neighbouring gorges, or communications with the seas. In the case, for instance, of the Hungarian-Viennese basin, it is at once evident from the surrounding levels, that when it was occupied with water, the Black Sea probably beat against the base of the Walaco-Servian chain, and must have communicated with the interior sea of Hungary by a large arm, occupying the valleys of Timok and Moratscha in Servia: and so of other localities.[3]

e. Abrupt changes, in the courses of rivers, are distinct indications of variation in the nature of the formations through which they flow, as well as of movements undergone by these. This law holds with small rivulets as well as large streams; for, if a rivulet meets a *dyke*, or, in any way, passes from one formation to another, its course is changed; and, precisely in this manner, the great bendings of all large streams seem brought about. Hence valuable indications from the course of the Niger, from the rivers of upper Hindostan, of Tibet and Tartary, from the bendings of the Yellow River, from the twists of the Rio del Norte in New Mexico, &c. &c. The operation and universality of this law are illustrated by a glance at the map, where the connection of the bending of its course with a change of strata is emphatically exhibited in the case of every important stream.

2. *The existence of* LAKES *in a Country, their form, and the system of rivers connected with them, constitute another source of information as to its geology. We have five well-marked and easily-discriminated species of lakes.*

a. Besides those small lakes, characteristic of every mountainous country, which are merely collections of water in accidental hollows, we have *crateriform lakes*, arising in peculiar actions, and belonging exclusively to certain formations. If these are in plains or valleys, without visible outlet, they must be regarded as the result of sinkings (*écroulements*) in arenaceo-gypsous masses, secondary or tertiary; but if they are surrounded by a crest of elevations, they are true *volcanic craters*, having sometimes an outlet, as the Lake Pavin in Auvergne. Thus, if some small lakes in the steppes of the Kirghiz are probably analogous to the lakes of depression (sinking) of Eisleben or Pyrmont; the trachytic lakes of Laach, of Bolsena, St Anne in Transylvania, of Gondar, of Urumiah in Asia, and of Nicaragua, are manifestly ancient volcanic cavities, somewhat increased by *écroulements*. This description of hollows may have been formed amid the granitic, sienitic, porphyritic, and serpentine eruptions, as well as amid the trachytes; but their preservation amid those older rocks is much rarer; they are there more or less broken,—a fact which much reduces the number that can now be recognised.

b. Lakes, in the crystalline schistous formation, have usually a very elongated form; they are surrounded with narrow bays, have inclinations more or less steep, and sometimes contain islands. These lakes are, in fact, masses of water filling the longitudinal or transverse clefts in the crystalline schists; and their shape is that of these clefts.

c. The lakes of the transition series are characterised by an oblong form, an undulating contour, very gentle slopes, their singular isolation in the midst of a country little elevated, or even flat, and also by their neighbourhood to hilly regions and the crystalline schists. They are so abundant in the globe, that an entire chain of them may be traced round the whole Northern Hemisphere. All the lakes which traverse North America are in this formation; and a series, very varied in form, stretches from north-west to south-east along the two slopes of the crystalline chain, which, with the Rocky Mountains, forms the chief mass of the northern continent. The same thing occurs in Europe and Asia. It is probable that the destruction of much of the transition series has greatly altered the contours of the Baltic, the White Sea, the Caspian, the Black Sea, and even of the Mediterranean; for their banks often exhibit crystalline schists, and, here and there only, the early sedimentary rocks that may once have covered them. The forms of these seas recall, besides, the shapes of the great lakes of North America, the figure of the Baltic resembling that of the Slave Lake, while Hudson Bay is not unlike the Black Sea, &c. Now, if it is proved that the American lakes have chiefly originated in accidents occurring within the transition series, may it not be concluded that these seas had a similar origin?

d. The lakes—often very deep—in jurassic and cretaceous districts, have characters altogether peculiar; some, occupying the bottom of cavities that have fallen in, very much resemble craters, as the Lake of Joux, or of Presba in Turkey in Europe. The Neapolitan Apennines contain numbers of this description, as in the neighbourhood of the Phlegrean Fields, &c., which, unless from the circumstance of the cliffs around them being secondary rocks, one would fail to distinguish from the openings of old volcanoes. Others in the same formation are really chasms engulfing rivers—situated generally at the base of cliffs, but also at the bottom of valleys. In such cases, the subterranean canals have no outlets sufficiently capacious for all the waters received; which accumulate at the surface and form lakes, whose size varies with the seasons. A third species peculiar to recent secondary calcareous soil, consists of those great lakes filling deep cavities in the calcareous mountains of the Alps and other chains, or at their meeting with the tertiary basins—as in the case of the celebrated lakes in Lombardy. All these—formed by the cleaving or destruction of the calcareous rocks,—are distinguished from such as arise from *écroulements* of the arenaceo-gypseous secondary or tertiary formation, by the fact that they are surrounded by steep cliffs or enclosed in shut-up basins; whilst lakes of the other kind are found only in plains or amid an undulating country, without any engirdling crest.

e. Lastly, the *lakes of the plains* are merely cavities of very slight depth, where the water is kept in by dykes, or merely by alluvium and sandy downs; in the latter case, they are a species of

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[1] At present, indeed, we can only venture to suspect that the bottom of the ocean presents a hollow whose configuration has a general resemblance to the *relief* of existing continents; for we are in the habit of considering it as established by our soundings—indeed by far too few, and for the most part taken too near the coasts—that the greatest depths of our seas do not surpass the altitudes of our loftiest mountains; that certain oceans are deeper than others, the larger ones being in general the deepest; and on the ground of these data, we have ventured on constructing artificial maps of the bottom of the seas of Europe, and of some other points of the globe's aqueous surface, especially near some coasts, of great and peculiar importance to navigation. But how many data are requisite to give certainty even to these very general deductions? And how many important problems remain unresolved, or rather not even undertaken? What, for instance, must geodesy and geology become, previous to being able to pronounce on the following subjects?—the identity, or only the approximation, of contour between the reliefs of the continents and of the bottom of the ocean; the direction, branching, distribution, and configuration (probably wholly peculiar) of submarine chains and groups of elevations; the probability of the non-existence of valleys at great depths,—the presence, in their places, of vast crateriform basins; the sort of defiles, slopes, and escarpments, as well as the localities of true submarine valleys or the beds of currents; the knowledge of the parts of the bottom of the ocean which are probably not covered by deposits; the appreciation of those geological formations there, which of course can never be examined; the knowledge of their distribution and their fossils; the distinction of formations which probably have never emerged, from such as have passed the surface of the waves to be again engulfed; the different deposits which have formed, or still are forming, at different depths, or near the shore; the diversity of these last in different zones and climates of the globe, &c. &c. As the waters cover the greater part of the earth, it is manifest that, even were the existing continents thoroughly studied, we would still be very far removed from a satisfactory acquaintance with our Planet.

[2] It is necessary to remark that, in all such speculations, the element of DIRECTION must be accurately, and not merely approximately, determined. But, as was long ago shown by the illustrious Humboldt, there are several features connected with *direction* that have been confounded; only one of which is connected with the theory of the age of the elevation and the similitude of the structure of mountains. Every chain contains five "*lignes directrices*," distinguished and defined as follows:—

1. The longitudinal axis of the entire chain, or of the whole upheaved ridge.
2. The line passing through the culminating points, or the maxima of height.
3. The line following the edges of the upheaved strata, or the axis of the fissure.
4. The line which divides the waters, or the watershed.
5. The line separating two contiguous formations in any horizontal section of them.

Now, the true line of direction is the first and third;—strictly speaking, perhaps the third only. It is the line along which that force has been exerted to which the elevation is due; and, in most cases, may be that lying at *right angles to the direction of the dip of the upheaved strata*. It were folly to pretend that the direction of the chains referred to in the text has been ascertained with even an approach to the suitable accuracy; and hence one important cause of the diversity of conclusions arrived at, by eminent geologists, regarding their place and age.

[3] It is necessary to observe, that the mere existence of a large basin is not always sufficient ground for the conclusion that it is occupied by a secondary or tertiary soil; for a very ancient formation, whose constituents are quite different, may assume the form of a lofty platform or plateau in the midst of mountains. Examples are to be had of such plateaux formed of highly inclined schists, cut horizontally, as if with a knife; for instance, in the *Landes* of Brittany. Some flat *steppes* are composed of horizontal secondary limestones, and some on the banks of the Orinoco of secondary sandstones, in no wise to be confounded with tertiary *superficiale*. Russia in Europe furnishes a striking example of the possibility of being deceived when deducing geological conclusions from the existence of low basins; for the enormous plains of that country are mostly composed of immense *horizontal* beds belonging to the *transition epoch*. Nevertheless, in cases like this, the related circumstances easily enable us to ascertain the true state of things.

lagune of more or less permanence. Exceptions are probably caused by the clefts or subsidences of some subjacent formation.

III.—Intimations of Geological Structure, derived from the Phenomena of Deserts.

Among the facts of physical geography of greatest importance towards deciphering the geology of a country, must be ranked the locality of DESERTS, or of places where water is rare, and vegetation almost or wholly wanting. Deserts, properly so called, infallibly point out districts of the globe into which, at a comparatively recent geological epoch, our present seas were prolonged, in great gulfs or straits; or which were occupied by actual *mediterraneans* that have now disappeared wholly or in part, and that gradually changed into fresh-water lakes previous to their escape or being dried up. It is, in fact, a physical impossibility that a true desert can expose any *ancient* formation; for every district of that description must, earlier or later, have been covered by a modern deposit, more or less fit for sustaining vegetation. Our marine sandy beaches, indeed, are the only formations now in progress, at all identical with deserts; and it is only the tertiary formation, whether of salt or fresh water, and especially the arenaceo-cretaceous system, which, by means of the variety of its soils, can originate expanses of sand *interspersed with fertile oases.* These facts suffice to demonstrate the modern origin of deserts in general, and fix, also, the comparative age of the red and white sandstones of Northern Africa. We deduce, further, that the formation of a desert presupposes the neighbourhood of certain soils, the presence of certain marine currents, and especially a position between great ancient chains of mountains which the water could abrade, in order to form extensive alluviums with the siliceous portion of their structure. To apply these conceptions;—we find in Egypt, in Nubia, in Dongola, towards the south of Sahara, in the regency of Tripoli, in Arabia Petrea, and Arabia Felix, and in Persia, the inferior cretaceous formation giving rise to moving sands and to rocks of friable sandstone, like those seen in Saxon Switzerland; whilst in the rest of Sahara and of Persia, in Egypt, in Mesopotamia, on the banks of the lower Indus, in Central Asia, and Western Australia, the tertiary strata, or even the alluviums, have the chief share in the production of oceans of sand, interspersed here and there with saline efflorescences.

IV.—Deductions from the Mineralogical and Palæontological Characters of a Country.

These characteristics are very determinate indications of the nature of the formations of a country; for each *mineral* has a special and distinctive position among the series of rocks; and every great group of formations is so distinctly characterised by peculiar *fossils,* that intimations regarding either—far more, regarding both conjoined—may be taken as a positive and certain index.

a. The topography of individual MINERALS, united to a study of their natural positions, acquires, from this mode of considering them, an importance of which few travellers have yet seemed aware; for even single lists of the metals of a country, or of its exchangeable products, might enable us often to raise the veil that covers its unexplored geology. For the same reason the composition of the alluvium of larger rivers may become an expressive indication of the formations constituting the neighbouring mountain chains.

b. It is unnecessary to refer to the use the geologist may make of collections, or even of single specimens, of FOSSILS. It is enough to recall the conclusions that Von Buch was enabled to draw from the examination of some fossil shells of America, and those which are intimated by the presence of certain crustacea on the coast of Malabar, Tranquebar, Coromandel, China, Japan, Java, the Philippines, Borneo, and other islands in the Malay Sea. If the *Cancer macrochelus* of China, and the *Portunus leucodon* of Manilla, denote the existence in these countries of a recent tertiary calcareous formation, such probably as that of Java; the *Grapsus dubius,* the *Gonoplax incisa,* and *emarginata,* are fossils of the tertiary clays of the *Sub-Apennine* epoch in Hindostan and the Sea of Malacca.

c. The subject of ERRATIC BLOCKS may be noticed under this head: for although these come generally from a distance, they are pregnant with information. Thus, the fact remarked by all travellers, that such blocks are scattered over North America in a line from north-west to south-east, from Mackenzie River to the Alleghanies and the Hudson, is sufficient ground for the presumption that, in the neighbourhood of this train of debris, there are very high chains; and that, to the east of the Rocky Mountains, there must be a vast hollow along which these blocks were rolled or floated. In fact, a low band or zone from north-west to south-east, is found between the Rocky Mountains, and another schistous chain to the west of Hudson Bay: and all American geologists agree that the blocks have come down in that direction. But the nature of these stones is manifestly an index of the constitution of the mountains from which they were originally broken off. Other blocks, not transported, but derived from the *decomposition* of rocks, yield likewise their instruction. Thus, the masses of native copper, found here and there near the great lakes of North America, reveal the presence of traps and serpentines which have been in part destroyed.

d. Information regarding a FEW SEPARATE FORMATIONS in a district, is often of signal importance towards unfolding the leading features of its complete geology, because we interpret these by the analogy of the structure of known basins; and the importance of this key increases in proportion as the basins to be studied are large in extent, and the strata, therefore, more fully developed. Thus in China, as soon as we have learned from travellers and mineralogical specimens that the great united basin of the Blue and Yellow Rivers is surrounded by chains of crystalline schists and granitoid rocks, we might be inclined to expect its interior to be occupied by the other more recent formations. But this supposition seems, at first sight, contradicted by the fact, that at the south of the Blue River a considerable portion of the maritime country is formed of these very crystalline schists and granitoid rocks—a branch from the central chain of the Asiatic Alps; whilst an ancient schistous formation constitutes the promontory separating the Yellow Sea from the Gulf of Pe-che-le. On the other hand, excellent coal, employed in certain provinces of China, indicates extensive transition deposits, towards the north-east of this empire, towards the south-east, and near Nankin; and, lastly, it is easy to recognise the secondary formations by certain minerals coming from the south; whilst others prove that tertiary formations abound through the flat countries. We thus meet with the entire series of formations known in Europe: they do not, however, appear to be arranged in *one* cavity, but in *two,* viz., that of the Yellow and that of the Blue River,—these being divided by a ridge of ancient crests. Resting, then, on such isolated data, is it not probable, according to the analogy of the formations of Europe, that these bands of deposits turn around the two basins referred to, and that the secondary Chinese soil stretches towards the north, to join that which forms the Asiatic Continent opposite the Japanese Archipelago, as well as the western coast of Kamtchatka? In the same manner, the geology of Northern Asia, as yet so little known, may be disentangled. We find there two great secondary basins—that of the Obi and Irtish, and of the Lena, separated by a broad ridge of crystalline schists, which is bounded by the transition rocks that form the northernmost promontories of Siberia; to the west of the Obi is the Oural wall, and to the east of the Lena, a mountainous triangle of schists and transition beds. To the south lies a series of mountains of various heights, obstructing perfect communication with any southern basin, unless near the higher courses of the Tobol and the Ischim. But secondary formations, particularly the middle ones and the jurassic, probably occupy these basins. Considerable alluviums, too, and even tertiary beds, here and there, must cover these last,—being chiefly met with in the basin of the Obi. In respect to South America, similar analogies induce us to think that, if transition rocks, covered by alluvium and tertiary deposits, occupy the narrowest part of that ancient strait of the ocean which separated the Andes from the former island of Brazil, some secondary rocks accompany, at least in a few places, the formations that bound—either wholly or partially—the schistous crystalline soil of the Andes, Patagonia, Chile, and Peru.

V.—Deductions concerning doubtful Points in the Geology of a Country, from the Labours, leading Facts, and various Civilizations of Humanity.

1. The various LABOURS of civilization are closely connected with the geology of the country wherein they are performed. If, for instance, we are discussing a country of low hills or of plains, surrounded by chains of crystalline schists (such as part of Asia Minor), a doubt would remain whether the heights are secondary or tertiary; but it might safely be inferred that the latter is the case, if the heights are cut by great roads or modes of communication. Wherever canals exist, they may be held as indications of a low division-line of the waters, and of the presence of tertiary formations. The Isthmus of Suez and its traces of an ancient canal, are an example; and similar considerations strengthen the conclusion, that a vast tertiary and alluvial soil constitutes the plain intersected by the great canal from Nankin to Pekin. All the formations, indeed, even when they rise into lofty crests, leave passages for roads; but whilst in an elevated crystalline or secondary chain, roads are rare—communication being there restricted to certain *cols,*—quite the contrary is the case among transition or secondary horizontal rocks, and especially amidst low tertiary hills. Still further; as the number of towns and villages increases, almost in a geometrical progression, as we pass from the ancient to the recent soils, the means of communication must also augment according to the same series of formations; likewise, almost every capital or very large city is built on tertiary soil, or on continental or maritime alluviums. Certain descriptions of civilization, even, result from the products of the soil where they are developed—as in the case of mining districts, and their associated peculiar industries; so that researches regarding the description of civilization characterizing a country geologically unknown, may not unfrequently guide the inquirer to its causes, and to a general opinion concerning the formations that prevail there. We receive valuable information, too, when antiquarian travellers speak of the caves of troglodytes, and of excavations either for dwellings or temples. It may be at once inferred, that these are calcareous caverns merely enlarged, or holes dug in friable, probably tertiary sandstones, or in basaltic tuffs, trachytes, pumice, or even, as with some of the pagodas of India, out of granitoid rocks. And some single and apparently indifferent and unconnected detail, will often enable us to choose among these various possibilities.

2. M. Boué dwells at considerable length on the effect of the physical conformation of continents in modifying the intercourse, mixture, emigrations, and warlike enterprises of different tribes and nations; but as these phenomena rather appear to receive elucidation from physical geography, than to be capable, in our present state of knowledge, of throwing definite light on the structure, whether geographical or geological, of unknown portions of the globe, we omit his observations. There is more direct interest, however, in his speculations concerning the distribution of the varieties of the human species over the earth's surface; for although not prepared to assent to his hypothesis regarding a diversity of Race, we find no difficulty in agreeing, that the farther back we go into the twilight of the past, the probability is the more forcibly impressed, that the seats of the earliest discernible civilizations were the mountainous parts of the several continents, from which the diverse tribes descended and diffused themselves gradually, as geological changes permitted the lowlands to be made habitable: so that the history of that diffusion is inseparably connected with the most important of recent geological changes, and—rightly interpreted—may become their index.

a. The early seats of the NEGRO RACE were unquestionably in the African triangle south of the Sahara and Nubia—a circumstance that confirms the geogenic conclusion, that this race was then separated from the White varieties on the north, by a vast sea; which certainly would not have been so likely, had Negroes been found on the southern coasts of the present Mediterranean. On the retreat of the great ocean filling the Sahara, &c., the population descended from the heights of Abyssinia, along the banks of the Nile, as far as its Delta; and, by intermixture with the inhabitants of Arabia and Hindostan, formed the great Hindoo-Negro people, by whom the Egyptian civilization was unfolded. The mass of the Negro race filled up Africa south of the Sahara, taking on the civilization of the Bochisman, the Hottentot, and the true Negro of the centre, in obedience to those climateric differences which we find acting with the same effect on the Botocudo of Brazil or the Red Indians of the north, and their compatriots in the Andes of Peru and the Mexican plateau. The fact of another black or bronze race being found in part of Australasia, along with peculiar animals and vegetables (where, however, the fossil bones of the *elephant* are found mingled with those of the kangaroo), seems to fix a geological date (in units of our human history) for the separation of this continent from Asia.

b. The varieties of the WHITE and YELLOW RACES—their differences of form, character, of language, and distribution—are wholly interwoven with geographical features which define the extent of their dwellings, and the diversity of their zones; and, with the important geogenic fact that the continental masses they inhabit *have always continued more or less united,* notwithstanding the existence of great mediterranean seas that have now disappeared. The enormous ridge of Asia, the comparative insignificance of the Oural, the hollow between that chain and the Caucasus, the dependence of the north of Africa on its great Mediterranean system, seem to be the chief causes of the dispersion of these fine races. Their varieties result quite naturally from the great number of chains from *east* to *west* in the continents they occupy; and from the numerous isolations produced by the intersection of chains from *north* to *south*; the former impressing the character of the *race,* and the latter, originating small divergencies—the effects of time and climate. All existing researches relative to the languages of the white races are favourable to the general ideas now expressed; for the myths of the Chinese, Hindoos, and Egyptians, speak with equal force concerning the descent of the populations from elevated localities, and their gradual occupation of countries formerly under the waters.

c. In the phenomenon of the ESQUIMAUX, living within the circle of polar ice, and in a constant struggle with nature, we discern elements for a final geogenic conclusion. This singular family, so superior to the Negroes, must certainly have become associated with the unfortunate country they now inhabit, in consequence of terrestrial changes of great importance. There are no highlands near them; nor any favourable centres from which they could have spread; and our only probable conjecture is, that they arrived there *when the climate was less rigorous than now.* To what epoch, then, can this event belong? Without doubt, the vegetables of the polar transition strata indicate a period at which the temperature of the poles was tropical; and when, instead of the light of the Sun, they must, during their long nights, have had some such equivalent as Auroras far more frequent, more brilliant, and more enduring than those of our time. This peculiar condition of Nature at the poles, must have changed by insensible gradations; but there seems reason to conclude that, even after the tertiary epoch, a distribution of heat quite different from the present one prevailed over the globe. The remarkable changes that have occurred in Greenland and Iceland during historical times, induce us to infer, that even at a period not far antecedent, the polar regions were not so frigid as to drive back any human being. Now, the abundance of fishes in these seas, the existence of useful animals, and the absence of beasts of prey, would—in conjunction with a climate generally mild—have quite sufficed to attract inhabitants; who, once acclimatized, may have gradually become fitted for those hard conditions which, through effect of slow cosmical changes, have grown up around them, and which they now endure. Geology and geognosy thus do not tend to maintain all the distinctions of the zoologist; but rather contract the number of types from which varieties have sprung, as effects of change and time.

IV.

The considerations are thus manifold, which enable the careful and conscientious Inquirer to accomplish the transition from the Physical Geography to the Geognosy of an unexplored district, in a manner true at least in the main, and, in so far, *leading in discovery*; and these presumptions may almost be converted into certainties when we have obtained *exact and detailed notions concerning the constitution of the countries surrounding the unknown Oasis.* It is unnecessary to remind the reader, that every geological survey of an extensive region consists, to a large extent, of this description of deduction; that is to say, after having ascertained the mineralogical constitution of a portion of a chain of hills or mountains, or even of a plain, we feel entitled, while following an exact geographical sketch of the accidents or peculiarities of the soil, to consider as entirely known that of which we have really examined only a very small portion; or, in other words, to fill up, through analogy, the unexplored portions, and so connect together the stations that have been visited. But this same process may be applied to a theoretical exhibition of the whole globe; and instances abound in which it has been successful. It required, for example, only the knowledge that calcareous formations of the *cretaceous* period exist in Egypt, to render it highly probable that a similar soil prevails in Arabia and Palestine, where these are calcareous; and this again involved an identity of the tertiary beds of the three countries. Long before the lower basin of the Euphrates and Tigris had been actually studied, M. Boué found no difficulty in deducing from the structure of Syria, that it consists of tertiary strata surrounded by very recent secondary rocks: and the valleys to the north of the Taurus, watered by the Frat and the Murad, indicated tertiary basins of a high elevation, previous to the discovery there, by the Russian engineers, of saline deposits of that epoch.—Following such a course, we may always advance, with secure step, towards the discovery of the geological constitution of a country by means of the study of its neighbouring territories: and, if the knowledge of the district A thus leads to the contents of B, the structure of B, in its turn, will enable us to reach the constitution of C; and so, as a farther step, we need not remain ignorant of the next region, D: but, of course, the verisimilitude of such conjectures must diminish, in a very high ratio, as the distance of the region increases from territories actually explored.

Hitherto we have assumed that the *geography* of the country scrutinized has been accurately ascertained; but even when this is not the case, valuable geological information of a certain amount of probability may be acquired regarding it, by the accurate study of *its form and contour.* When the windings of our continents and seas are narrowly examined, and the more essential peculiarities of their contours contemplated, it appears that Nature has not wrought after an indefinite number of types or models; but that, on the contrary, her fundamental types are very few. The whole of our land and sea, in fact, may be decomposed into a less or greater number of masses, either exhibiting all these fundamental forms, or merely a portion of them. For instance, the Atlantic has sometimes been compared to a mighty river; the Arctic Ocean to a mediterranean sea or huge lake, &c. Frequently the geographer has remarked the triangular character of the southern development of our continents; isles, and lakes, seas, and continents, have been assimilated as to form, such as Java and Lake Baikal, the Black Sea and Australia, &c. Europe may be divided into squares and parallelograms, by its mountain chains; into ovals by its basins; or even still more abstractly, as M. de Hauslab has pointed out, into grand ovals—the basins separated by triangles formed by the lofty ridges. But without dwelling on speculations so indefinite as these, let us observe, for the sake of illustration, what may be inferred regarding one unknown continent, viz., AFRICA;—frankly confessing, that our deductions have by no means the weight that might be claimed for them in the preceding cases.

The interior of AFRICA, to the south of the mountains near Lake Tchad, is wholly unknown to the geographer; and the positive geognosy of this great triangle is confined to a few notions concerning its three extremities, and six or eight points on its coasts. Our five grand groups of formations are found at its southern and south-western points; while along the northern base line, and at the north-east extremity, we have recognised only crystalline schists, intermingled with an enormous mass of crystalline and igneous rocks in Abyssinia. Navigators inform us that chains of mountains, some distance inland, bound the two coasts of Southern Africa, and that these are elevated and composed of crystalline schists in Congo; whilst all old narratives, alike of the aborigines and of travellers, induce us to suspect that a third chain crosses the continent, from the neighbourhood of Gambia. Now, it is of no moment to geologists, whether this chain is very elevated throughout, or, as is more probable, composed of successive terraces rising above each other, and greatly diminishing its apparent altitude. It is enough that it has no transverse cut or valley except that through which the Niger flows towards the Gulf of Benin, to entitle us to conclude that the interior of Southern Africa can in no wise resemble that of South America; and also, that if it contains secondary deposits, it has at least no vast tertiary basins—the probable theatres of an active and extended commerce. In Africa, we have only one break in this elevation of the soil—viz., directly across it. Rivers flow from it only at the west, north-east, and east; and at the only points examined, its mountains exhibit crystalline schists and granitoid rocks. Is it not probable, then, that Southern Africa is a great triangle, circumscribed by three chains, exactly like the peninsula of Hindostan? These regions have, in fact, the same form, and a very similar potamography: they both enclose very elevated districts, as well as plateaux and terraces; and the chains which bound them appear of corresponding constitution. If in Hindostan, then, the crystalline schists and massive igneous rocks abound, in comparison with all other formations, may it not be suspected that this holds in Africa likewise—the more especially since such appears to be the character of all the grand points that terminate the continents of the Southern Hemisphere? The middle of the Indian peninsula, again, being occupied by enormous eruptions of trap and basalt, is it too rash to suppose that igneous masses, not much dissimilar, are to be found in some parts of the centre of the elevated African triangle? Since in Asia the peninsula is bounded, towards the north, by the Himalaya and its parallel chains, is not the tradition probable, that in Africa there is a large upheaval, to the north of which is Sahara, a basin deeper than the Mediterranean, crowned by its Alps?—the chief contrasts being in differences of extent, and the levels of the chains and cavities of the two continents. Finally, analogy tells us, that the eastern chain of Africa may be composed of crystalline rocks, mingled with transition formations like the Eastern Ghauts of Hindostan; and the geognostic constitution of the southern part of Africa comes in support of this suspicion. If this great district conceals secondary formations, they will be found on the exterior sides of that triangular fabric; not in the interior or on the summits of the high chains. As to tertiary deposits, those of marine origin will be on the coasts, or very near them; or if the interior contains any, they will, like those of Hindostan, have formed the basin of fresh-water lakes. The Negro would thus, in all probability, inhabit a triangular platform, bounded by crystalline schistous chains, intermixed with numerous granitoid rocks, with some transition chains at the south and east, and even a few secondary rocks, especially of a recent epoch, near the south. In the centre we shall find basins of fresh water, forming plateaux, and an igneous region probably of a different epoch from that of Abyssinia, or that of the maritime borders of Sahara.—How far this conjectural sketch approximates to the reality, future explorers will unfold. But farther efforts in such a line of speculation would be unprofitable.

V.

Such being the laws and analogies by whose aid we have endeavoured to execute a first and *exploratory* sketch of the geology of the globe, it may be fitting—with that Chart before us—to inquire what general views are suggested by its great assemblage of phenomena.

I. The CLASSIFICATION of the Geographer is not, it is manifest, in agreement with that of the Geologist. The latter divides the globe into the following primary regions, viz.:—1. ASIA, with its great peninsulas, of which EUROPE and the States of BARBARY form the chief; 2. NORTHERN AMERICA, including Mexico and Guatemala; 3. SOUTH AMERICA; 4. The NEGROLAND OF AFRICA—the whole of this continent north of Sahara belonging essentially to the grand Asiatico-European quadrilateral; 5. AUSTRALIA, and its isles; 6. The ANTARCTIC REGIONS; 7. OCEANIA.

The first six of these important continental masses are nearly independent, having each a few satellites or subservient regions; and they all exhibit enormous nuclei of crystalline schists and massive unstratified rocks, whose magnitude and number are in close relation with the size of the continent whose skeleton they form. In America, and in the group of Europe and Asia, we have two such nuclei; but in Africa only one. Geologists are now inclined to view Oceania under a peculiar aspect, connecting it directly with the actual progress of the mightiest changes that have altered the surface of the earth. Within its immense range, we have at once the embyro of new continents, and the relics of immense masses that have disappeared, through submergence beneath its waves. According to the remarkable investigations of DARWIN, that long range of coral islands—atolls, or islands engirt by coral reefs—extending from the coasts of New Guinea, almost without interruption towards those of South America, are simply the crests (or fabrics reared on them by the madrepores) of an immense range of mountains belonging to a continent that during many ages has been *subsiding*. Of the form of that continent we have no intimation, except from the direction of its principal mountain-chain; to which, in some measure, it must have conformed. On the confines of this vast region of subsidence, great areas are grouped, within which the process of *elevation* is proceeding;—for instance, the coast of Chile; the Antilles; the volcanic chain or group to which the Sunda Isles belong; the district of Kamtchatka, &c. *Oceania* is thus an existing and impressive evidence, alike of the reality and magnitude of the oscillations which must have affected the Earth's crust or surface; and of whose actions its present or visible forms are the latest result.

Except for the Isthmus of Panama, and the elevation and drying of the former Mediterranean which covered Sahara, these six continents would be everywhere *surrounded by seas*. Previous to the emergence of the African desert, our Mediterranean probably did not exist, at least in its present state; and the southern part of Europe was then probably less fragmentary, and connected with its former appendix—the Barbaresque States. During the later upheavals among the Alps, the Sahara may have undergone its last elevation; and the enormous subsidences occurring between these two upheaved regions, produced the basin of the actual Mediterranean, whose accidental forms and relations induced the civilization of our Race to linger around its shores for some thousands of years.

If regarded from a very general point of view, and if Africa be connected with Europe, and Australia with Asia, our existing continents may be said to be made up of *three masses, of the form of the Americas.* Around the North Pole, with the exception of the northern promontory of Asia, the land terminates with the seventy-third parallel; from which circle it stretches south, along the American line to 55° south latitude—the African extremity reaching only 36°, while the Asiatic prolongation attains 40°. We shall not venture, with M. Boué, to consider these phenomena as probable results of the gradual flattening of the terrestrial spheroid through effect of its rotation—a throwing off, so to speak, of the land towards the equator; but certainly the peculiarity of this arrangement forbids its being regarded as accidental—pointing rather to some general, though obscure cause, in the figure of the solid on which the present continents are placed, and the mode of action or habitual direction of the forces existing within the interior of the globe.

II. The grandest feature of the continental masses is unquestionably those immense MOUNTAIN CHAINS, whose form and position are so closely connected with the Earth's past history. Dividing these imposing ranges into two great classes—viz., the chains which stretch along the parallels, and those whose direction agrees with the meridians—we discern, by inspection of the map, that the former class is the more important, and that the ranges belonging to it increase in number as we approach the equator. This fact—attributed by M. Boué to the greater centrifugal force at the equator—is unquestionably characteristic of the Earth's present condition; for around the equatorial protuberance we find a broad belt of chains of the first order, running east and west, viz., the central chains of Africa, Europe, and Asia; the submarine ridge, whose crests still appear in Oceania; and the coast chain of New Granada and Parima. In fact, all those great protuberances of the globe indicated by the pendulum and geodetic measurement, as well as the most elevated summits, lie parallel to the equator; and alongside of these, other lines may be traced, of enormous *ecroulements*, or succession of gulfs, seas, lakes, and terrestrial basins of a very low level;—accidents which are the natural result of the extraordinary upheaval of their neighbouring zones. This very striking feature probably indicates, that the rotation of our globe on its axis has modified and co-operated with the interior forces in producing the existing forms of the Earth's surface.

In the course of the previous remarks, reference has been made to the law, that *correspondence in direction indicates correspondence in constitution.* But it requires to be understood, that the correspondence referred to by M. Boué does not require absolute parallelism *in space*, unless the chains are in each other's immediate neighbourhood. It is simply meant, that each chain is similarly related to its own north. According to him, every formation of mountains on the globe stretches along lines not mathematically parallel, but for the most part *approximating to great circles of the sphere:* hence he is led, with the illustrious Humboldt and others, to conceive that these chains result from the *cooling of the globe, acting on the matters of which the globe's crust is composed; which again re-act on the liquid nucleus.* If we believe that the Earth has reached its solid state through a continued refrigeration, it must appear much more rational to suppose that in the course of the successive contractions of the oxidated crust, this crust has broken or split along parallel portions of great circles, than that these splits have taken place capriciously in all directions; a circumstance which occurs, indeed, with large molten scoriaceous masses that cool slowly. Along the lines of such clefts or splits filled up by incandescent masses from within, we should thus have the direction of mountain ranges. Possibly, however, a more extensive view of the subject may not confirm the fundamental hypothesis. It assumes that *the Earth's solid crust has continued comparatively thin* during the whole range of geological changes of which any memorial is left; and this is certainly not upheld by the only positive light which science has hitherto cast on the interior of our globe—the light obtained from physical consideration of the precession of the equinoxes.

III. A few interesting generalizations may be hazarded as to the mode in which the chief geological formations are distributed over the surface of our great continents. A glance at the map indicates the curious fact, that the geognostical complicacy of a region augments in proportion as its contour is broken and irregular,—an index, perhaps, of the number of upheavals to which it has been subjected. Africa and South America, whose coasts are quite unbroken, are of all the least complex; whilst North America, Australia, Asia, especially with its appendix—Europe, and the north coast of Africa, have no pretensions to simplicity.

1. Beginning our survey with the POLAR regions, we find these eminently characterised by the rarity of active volcanoes, by the predominance of crystalline schistous rocks, of granitoid rocks, and other massive and transition deposits, comprising in the last the ancient coal-fields towards the North Pole, which, however, very rarely pass the polar circle. Limited tertiary beds are found there, but they seem of an age comparatively recent. The want of secondary rocks indicates the absence of those essential climateric conditions, of the animals, &c., which have concurred in the production of such formations in other zones;—circumstances which have also prevailed during the earlier portion of the tertiary period. Within the north TEMPERATE ZONE, or perhaps between the polar circle and the equator, we find secondary and tertiary beds associated, in greater or less abundance, with every transition formation: but within the TROPIC regions, considered as a whole, the prevalent rocks belong to the tertiary epochs, especially the more recent, and to the group of crystalline schists, and granitoid masses. Very few transition formations are found there, and very few coal-fields;—in Africa, however, recent intelligence has informed us of one coal-field near the Orange River. The ancient carboniferous rocks seem to have their chief seats between the polar circle and the tropic of Cancer, where the vegetable masses appear to have been more easily mineralized, and to have been submerged and again raised above water, amid seas of limited depth, studded with islands: between the tropics at this time the excessive heat must have been unfavourable to luxuriant vegetation; and there then existed in those districts very little dry land.[1] In the few promontories stretching beyond the tropic of Capricorn, traces appear of a distribution and proportioning of deposits, not dissimilar to what prevails in the great zone north of the tropic of Cancer.

2. Of the numerous single phenomena, which have prevailed through all epochs of the world's history, the most noticeable is unquestionably the VOLCANO. Along with all igneous rocks, volcanoes belong to every zone; but our chart shows that they especially abound within the tropics, where also are enormous masses of igneous eruptions of every age. Volcanoes at present are chiefly in action in islands or along coasts, although exceptions exist in part of the American isthmus (the line through Mexico), and in Central Asia. Africa and Australia have no volcanoes; but modern igneous rocks, such as basalts, are found there. It will be seen, that throughout all periods, volcanoes and their products are distributed either along lines or clefts, or in circles around a grand central crater; but in the ancient volcanoes the crater has often disappeared, leaving instead, a lake or great *ecroulement*. The circular distribution seems to have been much more common in very ancient times: and several parts of the surface of the earth then bore a closer resemblance to the crateriform structure of the Moon. Of such granitic rings the best preserved are Bohemia and Ceylon, and probably the Montagnes d'Oisans: traces of the same phenomenon are found on the banks of the Middle Rhine, where, however, subsequent dislocations and upheavings have much destroyed the original form. The granitoid rocks of Egypt, Nubia, and Arabia, are likewise disposed in apparent accordance with their original connection with a vast circular surface. *Porphyries, trachytes, and basalts*, are everywhere easily recognised in connection with *lines* of elevation or dislocation; but they, too, are often found circularly disposed, especially if the minuter features of their distribution be observed, and minor centres of eruption are looked for.[2] Turning to *granites* and *sienites*, we find them belonging to every continent, and almost every country; but hypersthene sienites, porphyries, euphotides, serpentines, diorites, trachytes, and basalts, have appeared only in certain districts. It will, undoubtedly, be one day in the power of the geologist to divide the earth into regions, each characterized by the presence of one, two, or three descriptions of igneous eruptions; and thus to trace out the shiftings of the points from which fused masses have issued. But this, with other questions depending on it, belongs to the more difficult portions of the science.—The specialia of volcanic phenomena are elsewhere exhibited in the PHYSICAL ATLAS.

3. The facts ascertained regarding the *distribution of* ORGANIC REMAINS among the strata of the earth, are of high interest and importance; and enable us to hope, that at some early period a striking light will be thrown on that most mysterious and attractive of all themes—the order and laws of the evolution of Life. The following is a summary of what is now reckoned established:—(1.) That the general temperature of the surface of the globe has diminished from ancient times until now—although, certainly, with many *alternations*—seems indicated by the whole progress of its flora and fauna: but it is remarkable that, in the recent tertiary deposits, fossils are found, within the tropics, of species not identical with plants or animals at present living within that zone: although the climate existing there might seem to approach the most nearly to that of primordial epochs. Now, this would point to *a total climateric change even in the environs of the equator.* If we could be permitted, by other considerations, to attribute—with M. Boué—this great revolution to the gradual cooling of our spheroid, the ascertained laws of the rate of such a refrigeration would inevitably introduce us to Durations of a magnitude to the conception of which no Imagination is equal. (2.) The higher we ascend in the series of fossiliferous strata, the greater is the resemblance among the fossils of distant countries, and even of remote zones; and these resemblances characterize not genera merely, but species. It seems probable, therefore, judging from analogy, that the external circumstances capable of modifying the forms of organized beings, have likewise increased in complicacy during these successive epochs; and it may be inferred further, that the cause of previous high temperatures must have been one affecting the whole surface of the spheroid; insomuch that the diversifying influence of solar heat was counteracted by it to a very great extent.—But, while diversity among its organizations has thus increased as our globe's history evolved itself, the observation of the last thirty years has fully established the fact, that from the time of the earliest appearance of living beings as inhabitants of the earth, the complication of their different groups, and the multiplicity of their species, vary less than once was imagined from what is now discernible; and especially, that—when estimated by their relations to surrounding circumstances—neither

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[1] Some tropical parts of the Andes are exceptions; which is a strong reason for assigning a great age to part of that chain—the portion parallel to the great east and west ridges.

[2] There is a very striking analogy to this, quite common in the Moon—a long ridge, or furrow, being often visibly the result of an allineation of innumerable small craters, which of course diffuse around them, probably by minor cones, their products arranged in circles.

vegetables nor animals can be said to have ever assumed the *embryo* condition, but have always enjoyed a structure perfect and complete as now. (3.) The difference of the forms of organic life on the globe, at any two separate epochs of its history, appears directly proportional to the amount of time separating these epochs. It has long been known that the older the formation the less do its fossils resemble the relics of any flora or fauna belonging to the present epoch: the principle announced above goes farther than this. If we estimate the periods intervening between the deposition of any given rocks by the variety and thickness of the marine strata that separate them, we shall find that *in proportion to the difference of their ages is the difference of their zoological contents*—a proposition established even to an arithmetical precision, in the case of the tertiary strata, by the labours of M. DESHAYES on tertiary shells. (4.) As to the mode and order in which new species of animals have been introduced upon the arena of our world—whether to expel some old race, or to supply the vacancy caused by its removal—geologists do not consider that definite information is yet afforded by our most comprehensive review of the fossil relics. It is, indeed, beyond question that a stratified rock, superimposed on another, must rank *posterior* as to the time of its formation; but it cannot be so readily ascertained whether the deposition of this second rock was immediately and closely consecutive on the completion of the first, or whether ages intervened, during which the process of deposition was suspended, or its area shifted to some remote locality. It is not, therefore, easy to determine whether those breaks of continuity, those *lacunes*, which meet the palæontologist on passing from the fossils of one formation to those of the next, are intimations of destructions and creations of living species, or whether the history of life *seems* fragmentary, only because leaves have been torn from its annals at repeated intervals, and for ever destroyed. Geologists accordingly are divided on the momentous question, and, it may be suspected, have encountered it prematurely. The general opinion probably leans to that expressed by PICTET—that the SPECIES of animals belonging to any geological period have lived neither before nor after that period; that each formation has its special fossils, and that no well-defined species is ever found common to two deposits of different ages.[1] AGASSIZ, indeed, in his recent *Iconographie des Coquilles Tertiares*, has distinctly, and without compromise, denied the identity of any tertiary fossil with a living species; but notwithstanding the dictum of this earnest and admirable naturalist, one may be permitted—on studying the *Fauna Sivalensis*—to reflect on that beautiful manifestation of an Order, connecting, through insensible shades, the past with the present, and to suspend final judgment regarding a point so intricate, and withal so momentous in the Theory of the Earth.

IV. A brief view of the *changes experienced by the oceans and inland seas, from the most ancient times until now*, will fitly conclude our survey. This subject belongs to the grand and final problem of geology, the rational termination of all its researches—viz., the history and evolution of the GEOGRAPHY OF THE EARTH. Notwithstanding their inevitable imperfections, our contributions towards its solution are pregnant with interest.

1. First, as to the phenomena of the TERTIARY EPOCH. At that period, as the map shows, the Mediterranean, or another great and corresponding inland sea, covered the deserts of Sahara, Lower Egypt, and part of Arabia; for not till long after were its present contours defined, and its lagunes and ancient shores thrown dry. Later still, the Strait of Gibraltar probably continued shut, and the waters of our inland sea mingled, through the channels of the Red Sea and Persian Gulf, with those of the Indian Ocean; which seems to explain the analogy of the fossils of the middle and higher tertiary Mediterranean beds, with creatures still living in the Red and Indian Seas, and with petrifactions, of corresponding age, in the great basin of the Black Sea and Caspian. At the same epoch, too, the North Sea and the Baltic spread over the plains of Northern Europe: and another ocean, whose bed is indicated by the yellow colour on the map, stretched from the recesses of Siberia, and joined with the Mediterranean, by the Black Sea. Asia Minor contained small isolated basins, though the Black Sea, on the south and east, was confined by its present banks. In the south of Asia, a broad strait severed British Hindostan—then a triangular island—from the chains of the Himalaya and their dependents; and there existed, also, four great basins in the peninsula beyond the Ganges—two at least in China, one on the banks of the lower Amour, and two others in Siberia. As in the case of Europe, the centre of this continent was covered by an inland sea which has now wholly disappeared: other aqueous masses covered Persia, and probably formed—later even than the tertiary epoch—one basin dependent on the Caspian, and another annexed to the Indian Sea. In another district of the same continent, large portions of the isles of Sunda, the Philippines, Borneo, New Guinea, and Australia were at this period under the waters; and many volcanic peaks now existing, belonging to great areas of elevation, had not yet risen above the surface of the Indian or Malay seas. Turning to the map of America, we discern evidence of changes equally singular and extensive. The Gulf of Mexico then penetrated deep into Mexico, Florida, the lower basin of the Mississippi, and also into the basins of the northern rivers of South America. It washed the southern extremity of the Alleghanies, as well as the foot of the Ozark Mountains, and the Mexican and Colombian platforms. Farther north, a great interior ocean overspread part of this continent—comprehending the higher Mississippi, and the great Lakes. The Gulf of Mexico already contained a few islands composed of old formations—probably of much larger size than those whose shores it now washes; but its volcanic isles sprung into existence subsequently,—during that series of subsidences and elevations, of *ecroulements* of the chains along the ancient shore of South America, which drove the sea from the Ozark Mountains and the Alleghanies, and fixed its limits farther south. The northern part of the continent had three islands,—the basin of the St Lawrence separating the district of the Alleghanies from dry land on the banks of Hudson Bay and perhaps bending round to the Icy Sea. The platform of Mexico and Guatemala formed an appendix of the long isle of the Rocky Mountains; and the Ozark Chain advanced into the waters. The volcanoes of continental America, as we see them now, were contemporaneous with the formation of the Mexican and Mediterranean basins. In South America, we discern abundant proof that, at the tertiary epoch, the Atlantic covered the great strait between Brazil, the Andes, and Central Guiana, as well as between the Parima and the chain beyond the Orinoco; whence the mingling of the tributaries of this river and the Amazon, as well as the mode of the division of the waters between certain affluents of the La Plata and the Amazon. South America was then composed of three great islands; for the Isthmus of Panama did not exist.

2. The distribution of the oceans, during the SECONDARY EPOCH, cannot, indeed, be so definitely or surely discerned; but enough is clear to reveal a condition of things still more remote in character from what is in existence now. The tertiary seas, whose extent has been described, were, during this older period, in close and free communication with each other; for the elevation of the secondary rocks, especially in the old continent, tending to narrow all their shallow channels, diminished the number of their points of contact, and still more—their extent. The formation and upheaval of all the rocks of this group evolved this result; but perhaps their operation is most easily seen in the case of the jurassic and the cretaceous beds. The lower members of the secondary group defined the contours of many basins in Central Europe—on the banks, for instance, of the Rhine; between the Harz, the Erzgebirge, and the Thuringian forest; in England, Poland, Russia, &c. They also separated the great Siberian basin from the seas of Europe; and probably diminished the magnitude of the Chinese inland seas: Humboldt found them in the valley of the Orinoco, and Schomburgk in the interior of the crystalline district of Guiana. By the *jurassic* formation, on the other hand, distinct walls of separation were established in France, Switzerland, in the south-west of Germany, in Northern Hungary, Spain, and the north of Africa; and new shapes were imposed on the basins of Siberia, China, and Central Asia. Then emerged the *cretaceous* masses, completing everywhere the contours of the tertiary basins, particularly in the three south European peninsulas; at the same time, isolating Sahara from the Mediterranean, forming boundaries to Arabia, Mesopotamia, and Southern Persia, the coast of Tranquebar, the centre and north-east of Asia, perhaps China and Borneo, as well as Australia. They are likewise found on the two slopes of the Alleghanies, on the south-east slope of the Rocky Mountains in several parts of Mexico and Colombia, and among the Andes of Peru and Chile.

3. Stretching the eye yet farther into the past, traces of the condition of our continents during the TRANSITION EPOCH, although extremely faint, nevertheless appear. In *America*, six islands had arisen above the surface of the ocean. In *Africa*, a continent seems to have existed—or perhaps three or four large islands, viz., the three chains to the south, and the embryo of the Atlas of Marocco. In *Asia*, from three to five islands might be counted. Transition deposits had separated the north of Europe from its neighbouring continent, and marked out, on one side, the first contours of the basins of Australia, Hindostan, China, and Siberia; and on the other, those of Russia, Scandinavia, Central Europe, the British Isles, France, and Spain. Europe as a whole must have exhibited ten or eleven peaks or primitive islands, above the surface of those early oceans.

If one could regard these few hints as a reconstruction of the continental systems of the Ancient World,—there might be deduced, with considerable accuracy, the position and relations of the grand seas, and an outline of the system of currents arising in their interchange of waters. To discern this with distinctness, would, doubtless, enable us still farther to raise the veil from before the past; for the all-important action of such currents in the distribution of stratified rocks, might furnish a key to the problem of the place and extent of most of these great formations. But if we assumed that those islands constituted the mass and defined the form of the continents of previous epochs, we should forget that the Earth's crust is subjected not merely to a slow process of *upheaval*, but to a perpetual OSCILLATION,—that along with the appearance of every new elevation, there must have been immense submergences, carrying to the bottom of an ocean that will never be visited, extensive fabrics of former dry land. In the Pacific, peaks and islands are at present emerging, and perhaps are the first nuclei of the continents which, in future eras, shall adorn that expanse of waters; but if, before these periods revolve, Asia has sunk, and given place to a sea as unbroken as that which now rolls over the subsiding lands of ancient Oceania, the Geologist who shall then trace the slow rise of the regions at present emerging, will yet succeed in no wise in reconstructing the phenomena that now exist. Over the grand and ultimate questions here indicated, there rests a deep, and apparently a lasting mystery. The fluviatile deposits of the Wealden, or the fresh-water masses of the London clay, inform us that, at different and far-divided epochs, regions must have been connected even with our own islands, of a magnitude that sufficed to feed systems of rivers as imposing as the Ganges; but the constitution and form of these regions, their influence on the structure of British strata, the impress left by their existence and disappearance on those fragments of the past—the flora and fauna of our islands; such points must remain subjects, at best, for uncertain deduction and conjecture,[2] unless, indeed, we can suppose that our race and its sciences shall survive, until, in the course of terrestrial mutations, the floor of the ocean is raised once more into dry land—exposing its now hidden contents to examination.

B.

THE ELEVATION OF MOUNTAINS, AND THE CONTEMPORANEITY OF PARALLEL CHAINS.

I.

The doctrine regarding the relationship of parallel mountain-chains, on which a part of the foregoing dissertation is dependent, is undoubtedly the most enlarged geogenic conclusion, of the class next to the ultimate, on which Science has hitherto adventured. We shall therefore look more closely at its fundamental propositions.

1. The relation, in point of age, of every mountain chain, to the stratified rocks around it, is established by phenomena whose significance cannot be misunderstood. Overlooking the small exceptional cases whose extent and limits have been well arranged by Sir Henry de la Beche, it may be received as an indisputable fact, that all deposited strata were first laid down *horizontally;* and, therefore, that the existence of a stratified mass, in an inclined position, is an emphatic mark of the operation of disturbing and dislocating agencies in that locality. Now, since every range of mountains is accompanied by neighbouring rocks originating in the process of deposition, which are yet highly inclined—sometimes lying almost perpendicularly, and often even *overturned*—geologists have connected these effects of convulsion with the Force which elevated the chain; and thus, in the age *of the newest upturned stratum*, we recognise a date, *posterior* to which the appearance of these mountains must be placed. But on examining the associated phenomena more closely, strata are generally met with—posterior also to those upturned beds—which have *not* been affected by the convulsion that shattered the previous ones;—strata, in every case, *unconformable* with the masses lying on the flanks of the mountains, and very frequently stretching, in their original and undisturbed horizontality, to the very base of the chain, as if they were depositions from seas or lakes, of which that chain once formed the shore. Now, the crystalline masses must have been thrust upwards *prior* to the deposition of the oldest of these horizontal strata. The stratifications associated with the chains establish, therefore, *two grand limiting dates*, between which the mountain range must have been elevated; and as geology has succeeded in tracing the equivalents of most stratified masses over the whole earth—so that on meeting with a stratified rock in one country we can fix, without much hesitation, on its contemporary in another—it follows that the divisions of our globe's annals may be deciphered, and those eras of revolution separated, of which our mountain chains are the suitable and impressive memorials.

The epoch of the convulsion comprised between two such geological epochs has usually a definiteness as perfect as can be hoped for, when inquiry is dealing with operations not measurable by recognised and familiar units of time. It is frequently found, indeed, that the transition from the disturbed to the undisturbed strata is not accomplished by one single step or act: for instance, if the beds of deposition A, B, C, and D, are associated with the central chain, we sometimes find the first three inclined, though at different angles, or lying unconformably with each other, so that we pass from the highly disturbed mass A, through the less disturbed series B, and again through the still less disturbed series C, before we reach the system D, which shows by its horizontality that its position has undergone no change. But it by no means follows that an epoch of revolution *endured* in that portion of the globe from the close of the deposition of the strata A to the beginning of the formation of the system D. The right conclusion is, that within that period there were *three successive upheavals* in the same locality—one between the completion of A and the beginning of B; another between the completion of B and the beginning of C; and the third between the completion of C and the beginning of D—each of them precise and definite in itself. In the region in question, the interior forces have simply acted oftener than once; while to other districts they have communicated only one single shock, and then shifted for an outlet to some other part of the surface of the earth: but in all cases the action seems to have been precise, comparatively sudden, and of brief duration; for it fills up the interval between the deposition of two succeeding formations, during which no intermediate series of strata appeared. The enormous upheavals of the carboniferous system may be taken as an adequate illustration of the whole. The extent of dislocation of these vast beds has naturally arrested general attention. Although their massive limestones stand up almost vertically, and the coal strata, large or small, are twisted into every zigzag and unaccountable contortion, not a trace of this confusion, which has affected the entire of the system—involving its very last seam or layer in its changes—can, in many extensive districts, be found beyond the superior limit of the carboniferous masses, or has reached the magnesian limestone or other members of the Permian group that so often lie horizontally on the convulsed older rocks. In judging, too, of such actions by their apparent results, we discern—however gigantic these are—only a fragment or relic of the reality. The twisted strata remain, and also the upheaved granitic mountains; but other effects have vanished wholly, or are to be rescued from oblivion only as Professor Ramsay has reconstructed those immense secondary ranges of South Wales, out of the debris strewn through the valleys of the Mendip by the waters that destroyed them. Neither should it be supposed, that cataclysmal actions are at variance with the character of Nature as she works around us. In so far as this peculiar force is concerned, we seem, indeed, to have fallen on an era of comparative quiescence; but the Vesuvius whose unexpected paroxysm destroyed Pompeii and Herculaneum, was the same mountain on whose flanks villas had been built, and where hamlets and cities increased unchecked, during centuries of a previous and apparently a permanent repose.

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[1] Among other laws presumed as general on this very difficult subject, the following are announced in the memoir, by Sir R. Murchison and Professor Sedgwick, on the older deposits of North Germany—a memoir in so many respects of high importance:—1. The species found in a great number of localities, and in very distant countries, are almost always those which have lived during the formation of several successive systems. 2. The species that belong to a single system are rarely observed at great distances; and then they constitute local fauna peculiar to certain countries. More briefly—extensive geographical distribution is synonymous with persistency through time.

[2] It seems almost an error to speak of such deduction as *uncertain* after that masterly essay by the lamented EDWARD FORBES, entitled, *Connection between the Existing Fauna and Flora of the British Isles, and the Geological Changes which have affected their Area, especially during the Epoch of the Northern Drift.*

2. The means of ascertaining the age of a mountain chain are thus simple and indisputable, and the epoch to which it is referred is sufficiently determinate; but unless each range on the globe's surface were separately examined, we could not form, by the considerations now explained, any general conception of the course of the changes to which our planet has been subject. At this point, however, the geologist is aided to an unexpected extent by the important principle of the *contemporaneity of parallel fissures.* This principle has long been known to miners; it was, indeed, one of the earliest discoveries of the school of Freyberg. After much experience, considered and discussed with his singular acuteness, Werner reached the conclusion, that, in the same district, all the lodes of a mine of the same nature arose in *parallel fissures opened at the same time*, and probably simultaneously filled with metal at some subsequent period. The contemporaneity of parallel fissures and faults has become, in fact, a first principle in mining; and with this was soon associated the converse law, that fissures differing in direction also differ in age. The nature and extent of these fissures being considered—viz., that they are rents through solid strata, often of unfathomed depth, and also of immense length—it might, indeed, seem no unwarrantable boldness to extend the law to every dislocation undergone by the solid crust of the Earth. Regarded from the first as a high probability, this extension has grown into form, and been accepted with more or less reservation by most geologists who, since Saussure and Pallas, have largely scrutinised the phenomena of mountains. The subject very early attracted the attention of the veteran Humboldt. Von Buch traced through Germany four distinct systems of parallel chains; and our English Geologists contemplated the interesting and complicated ranges connected with Westmoreland from the same point of view. Should the inferences be confirmed, that strata elevated simultaneously generally assume a parallel direction, and—with whatever qualifications—that parallel strata are contemporaneous, it will not be easy to over-estimate the facility with which the Revolutions of the Earth may then be rescued from confusion. Observe, for instance, the Pyrenees and Upper Apennines. No longer would these two ranges be regarded apart, or even as a twin system—the one the prolongation of the other; but we should view them as single fissures in a vast zone, whose extreme boundaries lie probably across the Atlantic, and in Asia; and which bears on its surface, as results of the same pressure from within, chains of various orders and dimensions, from Cape Ortegal in Spain, eastward to the Persian Gulf. Thus also with the principal chain of the Alps:—its immense peaks and stupendous valleys would not then hold captive the imagination; for even it would shrink into one solitary fissure of a zone still mightier than the former; in whose strain and splitting by the energies from below, we might discern the origin not merely of the huge mountains hemming in the Mediterranean—the Sierra Morena, the Eastern Alps, the Balkan, the vast Atlas—but also of hoary Caucasus crowned by the trachyte cone of Elbruz, the Paropamisus, Hindoo Koosh, and the Himalaya—containing the loftiest peaks of the Earth. The map placed at the right of the chart containing M. Boué's will show the importance of the principle laid down for examination, more strikingly than any separate examples. The confusion of the masses heaped over the countries immediately north of Italy, wholly disappears; and we recognise instead, a mingling of remote and orderly operations,—the interference, and modification by each other, of grand processes all subject to law, and by whose regulated and appointed march, existing forms have been evolved.

II.

The subject we are now discussing, first received a systematic form in Elie de Beaumont's celebrated letter to Baron Humboldt, in 1832; and it has been treated anew, and attached to other unexpected generalisations, by the same French geologist, in his recent *Notice sur les Systèmes de Montagnes.* It is not within the province of the present essay to offer detailed criticism on the labours of M. de Beaumont; but as his views have taken strong hold of the rising geologists of France and Germany, and will therefore exert no slight influence on the course of inquiry, we feel it necessary to explain them briefly. In the first place, let us define what De Beaumont means by a *system of parallel chains* and its *great circle of reference.* On every common celestial globe two *great circles* of the sphere are distinctly marked—viz., the *Equator* and the *Ecliptic;* parallel to each of which are a number of *small circles*—viz., the circles of *Declination* and *Latitude.* Now, if a class of *refts* on the surface of the globe, or, what is virtually the same thing, of *chains of mountains*, should be found—whatever their distances from each other, or their relative lengths—to lie along these circles of declination, we would call those refts or chains a parallel system, and the Equator would be its great Circle of Reference. In the same manner, if another parallel system lay along circles of latitude, the Ecliptic would be its great Circle of Reference. It must be evident that, if *refts* or *chains* exist, of which *absolute* or *geometrical* parallelism might be predicated, it would be easy to determine the exact position of this great Circle of Reference in every case. But although M. de Beaumont claims, apparently on sufficient grounds, the existence of *virtual parallelisms*, he acknowledges that, *geometrically*, this is not more than approximate;—hence a preliminary difficulty in determining the exact position of that important circle. This difficulty the French geologist overcomes by aid of an assumption—supported by all his views of the dynamics of the globe, and otherwise by no means improbable,—the assumption, viz., *that the zone in which each actual system of parallel lines of elevation on the Earth's surface is comprised, is bisected, or nearly so, by its great Circle of Reference;* and, on the ground of this hypothesis or assumption, he has fixed a point in the midst of each of his systems, through which its Circle of Reference must pass—a point named by him the *Centre of Reduction.* It is not requisite to say that Elie de Beamont is too accurate an observer and too sound a philosopher, to have failed to observe how large an amount of what is arbitrary must be involved in perhaps every one of his special or positive determinations as to the different Systems; indeed, he speaks expressly of all these as provisional. The opportunity is indeed a pleasant one that enables us to acknowledge the conscientiousness which has conducted him so well, through so much labour of collection and *discussion.* One other preliminary remark;—the relative directions of these various parallel systems will evidently best appear through the relations of their various great Circles of Reference; which relations can, by easy geometrical methods, be expressed graphically or in numbers, by transporting the various great circles to the centre of reduction of some one system. The small map on the left shows the relations of these directions, transported to Milford.

The following is a table of the parallel systems which M. de Beaumont considers at present recognisable. But although believing his determinations highly probable, he acknowledges throughout, as we have already said, that in so far they must be considered provisional.

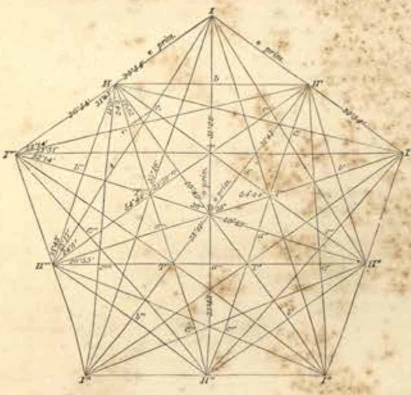
SYSTEMS OF EUROPEAN PARALLEL CHAINS.

Systems.	Directions, reduced to Milford.	Regions in which the Systems exist.
I. Vendée.	N. 25° 14′ W.	La Vendée, Brittany.
II. Finisterre.	E. 22° 10′ N.	Brittany, Normandy, Sweden, (?) Finland. (?)
III. Longmynd.	N. 24° 24′ E.	Longmynd, Brittany, Normandy, Saxony, Sweden, Finland.
IV. Morbihan. Lower Silurian. Upper Silurian. Tilestone.	W. 36° 35′ N.	Brittany, &c.
V. Westmoreland and Hundsrück. Old Red Sandstone. Carboniferous Limestone.	E. 41° 12′ N.	Wales and adjoining English Counties, Westmoreland, the Grampians, Ireland, the Eifel, Nassau, the Vosges, France, Bohemia, Scandinavia, &c.
VI. Ballons. Millstone Grit.	W. 6° 17′ N.	Many places in Great Britain and France. Extends to the Old Red Sandstone of Norway, and the Devonian and Carboniferous Rocks of Russia.
VII. Forez. Coal Measures.	N. 21° 51′ W.	Several parts of France, Dudley, (?) Crossfell, (?) Derbyshire. (?)
VIII. North of England. Rothliegendes. Magnesian Limestone.	N. 7° 27′ W.	Central ridge from Derbyshire northwards, Malvern, &c.; Department of Loire, &c.; Island of Gothland; north of Russia.
IX. Netherlands and South Wales. Grès de Vosges. Magnesian Conglomerate of Bristol.	E. 11° 54′ N.	Discontinuously from the Elbe to St Bride's Bay, and southward into Brittany; south of Ireland, Derbyshire, Netherlands, Thuringia, south of Russia, &c.
X. Rhine. Trias { Grès Bizarré. Muschelkalk. Marnes Irrisées.	N. 11° 8′ E.	Vosges Mountains; centre of France; Dudley and Coalbrook Dale; Ireland; Scotland; Scandinavia.
XI. Thuringerwald. Lias. Jurassic Formations.	W. 26° 22′ N.	Thüringerwald; France.
XII. Mont Pilas and Cote d'Or. Lower Cretaceous Group. (Lower Greensand, Gault and Upper Greensand).	N. 42° 27′ E.	Eastern and northern parts of France, Saxony, Vosges, England (Oolitic escarpment).
XIII. Vercors.	N. 0 14′ W.	Age not determined.
XIV. Mont Viso and Pindus. White Chalk (Upper and Lower). Nummulitic Formation.	N. 31° 55′ W.	Mont Viso (French Alps); centre of France; Greece.
XV. Pyrenees. Eocene of the Paris Basin beneath the Grès de Fontainebleau.	W. 14° 14′ N.	Pyrenees, Italy, Sicily, Greece, Carpathians, south-east of England (Weald, &c.)
XVI. Corsica and Sardinia. (Grès de Fontainebleau.)	N. 11° 21′ W.	Corsica, Sardinia, upper parts of Loire and Allier, Rhone, Hungary, Syria, Red Sea.
XVII. Isle of Wight and Tatra. Calcaire d'eau douée superieur (Paris Basin).	E. 14° 13′ N.	Isle of Wight, Tatra (a mountain south of the Carpathians), Greece, Eastern Alps, Jura.
XVIII. Erymanthus and Sancerrois. Fahms de la Touraine. Molasse (containing shells).	E. 31° 52′ N.	Greece, France.
XIX. Western Alps. Terrain de Transport Ancien.	N. 18° 30′ E.	Italy, Sicily, Northern Africa, Hungary, Poland, Crimea, Asia Minor, the Hartz, Cantal, and Mont D'or, Norway, Sweden.
XX. Principal Chain of the Alps (from Le Vallais to Austria.) Diluvium.	E. 23° 50′ N.	South-east of England, north of France, south-west of France, Spain, shores of the Mediterranean, north of Africa, Atlas, Caucasus.
XXI. Tenare, Etna, and Vesuvius.	N. 26° 15′ W.	Greece, Italy, Sicily.

Such are M. de Beaumont's European systems. Instead, however, of conceiving them restricted to this quarter of the globe, he has attempted to trace several of them into Asia, Africa, and America; but as the evidence on which these wider conclusions rest is comparatively indecisive, we shall not follow him through his remoter excursions. Abstaining, in accordance with our purpose, from minute criticism, we shall venture nevertheless three general remarks. (1.) It cannot be questioned that the existence, or highly probable existence, of such an array of systems, with regard to the various dislocations in each of which the characteristics of *contemporaneity* and *parallelism* may be even approximately predicated, is not conceivable, unless on the ground that some great law or mode of action of the Upheaving Cause constrains such *parallelism* and *contemporaneity.* The point really to be determined is the amount of probability that can be challenged on behalf of each individual System; and, we fear, this is still the weak part of De Beaumont's speculation. It were extravagant to claim that the characteristic of *contemporaneity* has been specifically determined for all these parallel dislocations; and it is equally certain that, with regard to very many of them, the attribute of *parallelism* remains quite uncertain unless within large limits. Nevertheless, with all deductions, enough seems established to constitute an assurance that the speculation is on the *trail* of some highly important order of Nature. (2.) If any dynamical law of upheaval, necessitating the conjunction of *parallelism* and *synchronism*, had been definitively established, approximations of an inferior order would suffice to constitute a *System of Mountains.* But *no such dynamical law is at present clearly recognised.* The reader must not confound actions necessitating the synchronisms of parallel *metallic veins*, with actions whose energy is alleged to extend sometimes over more than the fourth part of a great circle of the sphere. The former class of phenomena are deducible from the simple fact that a certain parallelogram or extended space on the surface of the earth has been subject to upheaval (compare a summary of the investigations of Mr Hopkins, in section C of this paper), while the latter are connected with problematical theories concerning the cooling of the earth and the thickness of its crust. In the task of constituting his "Systems," therefore, M. de Beaumont is not entitled at present to invoke the aid of *theory;* the probability of each system must be determined by *induction* alone. (3.) In none of this class of inquiries are we entitled to connect *absolutely* the characteristics of *parallelism* and *synchronism.* Not only may parallelism exist without contemporaneity (see section C), but contemporaneity may often have *divergence* as its essential characteristic. It is certain that the upheaving force has often acted as if explosively *from a centre,*—not merely uplifting a large extent of surface. Hence *craters of Elevation* with their diverging fissures; hence the phenomena of the Lake District of England, so acutely analysed by Mr Hopkins; hence especially the phenomena of dislocation in the Moon, where contemporaneous refts lie along radial lines. And hence therefore, several modifications in M. de Beaumont's Systems.—The reader is further referred to Mr Hopkins' valuable Anniversary Address to the Geological Society of London in 1853.

III.

But M. de Beaumont has adventured on a farther speculation—no less daring than novel. He thinks he has discovered a principle of *geometrical symmetry* among these established great Circles of Reference, and which may likewise comprehend the positions of all others whose existence shall henceforth be ascertained. In order that the reader thoroughly understand the grounds of this proposed effort to ascend among the highest generalisations of Inductive Geology, it is necessary that we explain farther De Beaumont's method of *transporting* or referring the directions of those Great Circles to some *one* centre of reduction, so that their angular relations or directions may be easily compared. The map given at the left hand of the large chart shows, as we have already stated, the directions alluded to, at *Milford.* The several lines on that map are found as follows. Suppose it were desired to transport the direction of the system of *Longmynd* to Milford,—through Milford draw an arc of a great circle of the sphere, at right angles to the Circle of Reference of Longmynd; and then, through the same point, draw another great circle at right angles to that arc: this second great circle will be the direction of the system of Longmynd as seen at Milford. The whole of the Circles of Reference thus transported to any one point, it is sufficiently clear that their relations of direction, or their symmetry of disposition, must—should symmetry exist—be more readily discerned. To enable himself to examine the subject the more carefully, De Beaumont executed three such maps, reducing all established Great Circles of Reference to three different points—viz., *Milford*, *Binger-loch* on the Rhine, and *Corinth*. Not satisfied, however, with mere graphic representations, he executed laborious calculations, determining exactly the angles among the directions reduced to these three points; and in a fourth table he has given the *means* of these three series of angles. Is there, then, any indication of law or geometrical symmetry among the relative directions of these *great Circles of Comparison*, or among the mean directions thus found? After arranging the angles according to magnitude, and dividing the whole set of systems, in reference to their disposition, into *groups* and *lacunes*, De Beaumont has persuaded himself that indications of symmetry are strong and unquestionable. For instance, such facts as the following may be read off, from an arranged table of these angles: the angle between the system of the *Pyrenees* and that of the *Netherlands* is 22° 14′; between that of *Vercors* and that of the *Longmynd*, 22° 10′; between that of *Forez* and that of *Vercors*, 22° 24′; and for other pairs the intervening angle is likewise found very nearly the same in value. But as it is only with great circles *belonging to some symmetrical figure*, that different *pairs* will be frequently found inclined to each other at equal angles, De Beaumont infers from facts such as the foregoing that the great circles of his different systems belong in all probability to some symmetrical figure, which will be indicated by their intersections on the surface of the sphere. "Such evidences of symmetry," says Mr Hopkins, "will doubtless be felt to be extremely vague. It is not, however, to be regarded as a part of the final evidence on which this part of our author's theory is made to rest, but rather as affording him some indistinct and distant view of that symmetry which he appears to have been persuaded must really characterise some system of lines of which his *great circles of reference* form a part." The great task of De Beamount yet remained—viz., to find that general symmetrical system which would comprehend those special instances of symmetry, as well as all others that have been found or may be found to exist, even although not so emphatic. It is not improbable that the labours of this distinguished geologist, towards the end in question, have not been crowned with success; nay, there is reason to think that the scheme he has evolved is, from its very nature, not susceptible of proof; nevertheless, his labours have been very great, and so conscientious that we cannot doubt his readiness to cast aside his present conclusions, on clearer sight; and that, should truth finally dawn on him, whether from his own thoughts or those of others, he will be found worthy to say with John Kepler, "*Totam Harmonices naturam, inter Motus reperiri; non eo quidem modo, quem ego conceperam animo; pars hæc est non postrema mei gaudii; sed diversissimo alio, simulque et præstantissimo, et perfectissimo.*"—De Beaumont's conception of the symmetry actually existing, will be best understood by aid of an illustration, much simpler than that which he imagines to represent the true case. Let the reader bring before his mind a regular cube, or regular solid with six square faces, and imagine a sphere described around that cube. It is evident that the *sides* of the cube, extended to the surface of the sphere, will constitute great circles; and that, if so extended, the surface of the sphere will be divided by them into *six* great symmetrical portions. But the great circles thus subdividing the sphere's surface would only be the *primary* circles of such a system. A great number of others would be related to that system; for instance, the great circles projected by the *diagonals* of each bounding square—those projected by lines joining the middle points of each square's opposite sides—or those projected by lines dividing, in any symmetrical way, the angles of each square. It is clear that, however complex or numerous the circles thus projected on the surface of the sphere, they would necessarily manifest a *symmetry*—that is, their angular directions with each other must in every case be referable to the character or properties of the original or normal figure—viz., the projection of the face of the cube, or the symmetrical sixth part of the entire sphere. The same thing would plainly occur had the sphere been described around any of the *regular solids*; and—as is sufficiently strange—it has occurred to De Beaumont, even as it did at first to Kepler, to inquire if the multitude of facts in his possession can obtain a solution from the properties, if any, of these regular solids. Our inquirer has not made a random choice. Correctly or otherwise, he has endeavoured to reach his conclusion through elaborate induction. And that conclusion is, that the *dodecahedron*, or regular figure with twelve equal and symmetrical faces, each of which is a *pentagon*, is the figure representing the symmetry of the Great Circles of Reference of all known, and probably of all existing Systems of Mountains. The five great circles constituting the projection of the faces of the pentagon, along with such subsidiary circles as are referred to above, constitute a network on each twelfth part of the surface of the sphere, which De Beaumont terms his *reseau pentagonal*. It would be quite wrong, however, to suppose these subsidiary circles to be chosen capriciously, or without regard to the general spherical symmetry of the System. For instance, a great circle drawn from the centre of any pentagon to one of its angular points, passes, when prolonged, along the common side of other two adjacent pentagons; and so of others. M. de Beaumont has endeavoured to represent, in his fifth map, the multitudes of intersections and relations that occur within one of his twelve pentagons; and, as no critical view can easily be formed respecting his scheme, unless by means of such a representation, we reproduce his plate in a rough woodcut.



The number of principal circles constituting the *reseau pentagonal* will receive partial illustration from this reduced map. To complete the *reseau* of the sphere, each of the lines represented in one single pentagon must be produced into a great circle, and the same process performed for every pentagon. It is easy to see that the number of circles whose position is thus determined is immense. Of course, M. de Beaumont does not pretend that each of these circles represents the Circle of Reference of a system of dislocations; but he endeavours to show that all known Circles of Reference coincide, within moderate limits of error, with circles belonging to the pentagonal *reseau*; and he thinks himself entitled to infer, that all circles of reference belonging to whatever systems of dislocation are yet to be discovered, will be found connected with those already known to exist, by this well-defined geometrical law of symmetry. On calculating the *angles* included between the principal circles of the pentagonal *reseau*, and comparing them with the series of angles previously determined as the relative directions of the great Circles of Reference, De Beaumont found an accordance sufficiently near to afford, as he conceived, a strong sanction to his theory: nevertheless, the testing question was clearly this, *Can such a pentagonal reseau be applied to a terrestrial globe, so that the Circles of Reference shall actually coincide with great circles determined by that reseau?* The French geologist, in undertaking this new inquiry, was fully aware alike of its difficulty and importance, and certainly he has spared no labour in the conduct of it. After various tentatives, he adopted *Remda* in Saxony as the centre of the *reseau*, and imagined it laid down on the globe so that the line D H should coincide with the great circle of the system of Tenara. In this case no fewer than ten established Circles of Reference are found to pass through D, and to coincide very nearly with chief circles of the *reseau*. These systems are—

I. System of Tenara.
II. System of Thuringerwald.
III. System of the Rhine.
IV. System of the Ballons.
V. System of Finisterre.
VI. System of the Netherlands.
VII. System of the Cote d'Or.
VIII. System of the Western Alps.
IX. System of Corsica and Sardinia.
X. System of the North of England.

The reader is farther referred to De Beaumont's map, No. 5; and his memoir must be consulted for an adequate statement of all the probabilities which he thinks can be claimed in support of his Law of Symmetry. We are constrained to say, however, that, in the present case, the objection brought forward by Mr Hopkins seems to invalidate to a very great degree all existing favourable evidence. It must be recollected that the great Circles of Reference are as yet only provisionally settled, and that the amount of *arbitrariness* involved in the choice of a *Centre of Reduction* throws still further uncertainty over the angular relations of these circles. Now the important question is, whether, within these acknowledged limits of error, *several* great circles of that innumerable band constituting the pentagonal *reseau*, are not *always found*,—in other words, whether *it can in any instance be fairly said that the Circle of Reference coincides with one special circle of the reseau, and not with another?* A full review of the subject has not convinced Mr Hopkins that this can ever be alleged; on which ground this geometer concludes as follows: "The inference I should draw from the approximate accordance of the two above-mentioned series of angles, as well as from an inspection of the map on which the *great circles of reference* are delineated, is merely that the physical cause to which lines of elevation are to be referred has so acted as to distribute these lines pretty equally with reference to different points of the compass; but I confess that I can see no solid grounds for the induction that the author's great circles of reference have any necessary connection with the pentagonal *reseau*."

IV.

The gigantic phenomena of whose relations we are treating, certainly do not stand out singly or unassociated, among telluric changes. Although not perhaps connected by any *geometrical symmetry*, they unquestionably have proceeded according to some fixed and vast order; regarding which it is not improbable that we shall receive our earliest hints, from correlations discerned between these systems of mountains, and other physical attributes of the Globe. Now, many intimations have reached us, that the internal condition of the earth, as to action or repose, may be closely connected with the varying play of the magnetic or electric forces: nay, it is not unlikely that a far more thorough metamorphism than has yet been suspected to exist—a metamorphism involving the shifting of huge masses as its accompaniment—has resulted from the persevering influence of these potent agencies. With M. Neckar de Saussure, therefore, we are not disinclined to recognise a possible connection between the disposition of existing mountain-chains, and *the distribution of the magnetic forces over the globe*. It has been conceived by this able Inquirer, that there is a marked concordance between the *prevailing direction of the stratified masses, and the bendings of the curves of equal magnetic intensity*. M. Neckar does not speculate on the significance of this relationship—not venturing to discriminate which of the two is *cause*, and which *effect*: nor are the irregularities of the magnetic curves sufficiently ascertained to justify any attempt to follow the relationship through confused districts, where, as in the region north of Italy, numerous zones intermingle, and the order of the upheaving forces must be disentangled by the separation of many distinct chains. Considering them, however, with the forbearance due to avowed approximations in regard of a new and extensive scheme of relations, the following facts, which are easily traced on a map of the lines of magnetic intensity, seem possessed of remarkable interest.

1. On the west coast of Europe, the direction of these curves is chiefly from south-west to north-east, which has long been remarked as the prevailing direction of stratification in these regions. In Scotland especially, the curve almost coincides with the Grampian chain; and, as it becomes less northerly before reaching Portugal and Spain, we find it here also in singular accordance with the Sierras, which crown the elevated plateaus of that peninsula. Before entering Sweden, the line of intensity 1·4 tends to recurve in order to sweep down the plain of Russia in a direction towards the south-east; but as the line 1·5 passes northward *parallelly to the Norwegian coast* previous to recurring in the Arctic Ocean, there is little doubt that an intermediate line pursuing a course through the Scandinavian Alps will be found isodynamic. The path of these curves through European Russia does not diverge greatly from the direction of the stratifications of its immense plains; but on reaching the Oural the concordance is complete; the magnetic line of 1·55 passing there from north to south.

2. In the south-west of Europe, the elevated zone of Spain lies in the direction of isodynamic curves; but its fracture by the Pyrenees—also a geological anomaly—indicates an exception to the law, or at all events, an irregularity in the curve in that locality, which is not yet detected. Farther east we reach the Alps; and notwithstanding the broken and complex nature of these territories, we are struck by a surprising coincidence—the magnetic line following, with much precision, the break in the great Alpine chains. As explained above, the interference or intersection of two upheavals causes this important range of mountains to seem to alter its direction, from south-west and north-east to another almost easterly; and in the intermediate neighbourhood of this break, the magnetic curve bends similarly, sweeping through Asia, along the peaks of the Caucasus, Taurus, the Paropamisus, the Himalaya, and the Chinese ranges, when it again points northerly, following the Yblanoi chain towards Behring Strait.

3. In the interior of Africa, of course, no curves have been traced: but on connecting observations obtained near the coasts, the isodynamic curves appear to coincide with the direction of the still hypothetical chain on the south of Sahara; and with the lofty sea-coast ridge, which unites the towering peaks of Abyssinia with the Table Mountain. It is likely, also, that there is a node, or rebending of these lines, within that vast sinuosity of which the Gulf of Guinea is a part.

4. After Europe, North America is best known to geologists; and throughout its wide extent, the direction of the stratified masses corresponds with the isodynamic curves. Over the eastern surface of the United States, we recognise the direction of south-west to north-east, as characteristic of both phenomena; and in the regions near the Pacific, the magnetic curve lies along the line north-north-west to south-south-east, which is the course of the Rocky Mountains. In Mexico, Humboldt found the stratified beds lying parallel to the Cordillera of Anahuac, or from north-west to south-east—also the direction of the magnetic curve passing through them; and a similar accordance is discernible near the littoral chain of Venezuela, in the countries between the flats of the Orinoco, and the basin of the Rio Negro, and the Amazon. So far as is yet known, the Andes of South America are flagrant exceptions to the rule, for they are *crossed* by curves of values from 1·0 to 1·5; but to counterbalance this, lines appear to stretch downwards from the southernmost promontories of America and Asia, straight towards those massive headlands within the Antarctic regions, which our adventurous countryman has discerned as our first intimation of a continent hidden, until now, within the barriers of Polar ice.

C.

THEORETICAL CONSIDERATIONS RELATING TO THE ELEVATION OF MOUNTAINS.

The laws concerning the relations between the parallelism and contemporaneity of Mountain-Chains, possess, as presented above, only the certainty and extension generally due to *empirical laws*, by which effects are grouped together, without reference to their causes. Such inquiries, however, in their ultimate and only satisfactory state, ought to exhibit how effects so remarkable may flow from fixed and probably simple principles; and thus alone shall we be able to estimate the extent and bearing of the relations we have discerned, and see our way through their apparent failures and ambiguities. As hinted in several parts of the previous memoir, attempts have not been wanting to elucidate the laws in question by reference to the supposed refrigeration of the globe; but our best lights here are only dim and unsatisfactory.

The true dynamics of geology owe their foundation to Mr Hopkins of Cambridge. Avoiding all ultimate theories, he rests simply on the fact, that upheavals do take place, not of chains of mountains merely, but, as investigation demonstrates, of vast zones, of which these ranges are the mere accidents; and the question is, Whether by aid of the common laws of Force, we may not deduce some general features necessarily characterising all such dislocations of the earth's crust? Mr Hopkins' inquiry—now extended over several highly instructive memoirs—has three special divisions.

I. The simplest case of elevation is that in which the upheaving force is limited to a small area—say to a point on the earth's surface—its intensity diminishing according to distance from that point. The upheaval under such circumstances will manifestly be confined to a limited circular region, and must result in what is now well known as a *crater of elevation*. The splits or fissures of the upraised strata will probably be confined to a single system—a system, viz., along radii from the central point; or there may exist separately or conjoined with the former, another system dividing the distended soil into concentric rings. The phenomena attending such upheavals had been fully discussed previous to the investigations of Mr Hopkins, by Elie de Beaumont and Dufrenoy—perhaps with an aim at too high numerical precision—in their interesting memoirs on the volcanoes of Central France; where every attainable elucidation is thrown on the phenomena of circular elevations. It has been often remarked that this species of dislocation seems to have prevailed among the older epochs of the history of the earth: and certainly it has affected most abundantly the existing surface of our Satellite.

II. The upheaving force, however, instead of being confined within a small district, may be diffused below a large tract or zone: and the simplest mode of considering its operation in this case, is to neglect the shape of that zone, unless in regard of its two dimensions, length and breadth. Now, if such a zone be elevated, it must, during the whole course of its upheaval, be *stretched*, or subjected to *tensions*, which incline to tear or split it; and a little consideration will show, that (as results from Mr Hopkins' Geometry) these tensions must reach their *maxima* in two directions; one set inducing the zone to split in the direction of its length, and another acting at right angles to these, and tending to produce fissures along the zone's breadth. Without going farther, then, we obtain an insight into the phenomena of *transverse valleys* uniformly characterising every mountain-chain; and the reason is seen why mineral veins are generally found associated in two systems, at right angles to each other. A very effective attempt is made by Sir R. Murchison, in his recent Memoir on Scandinavia, to explain the broken outlines of these northern regions by this prolific principle.

But if, in either of these directions, the zone yields in more than one place, it must do so *along parallel lines*. The direction of the *length* of the zone being that of the *maximum* of one set of tensions, it is plain, that whether the zone splits, in obedience to these tensions, in one place or many, the fissures must assume *that direction*, and no other; and as the zone must here be supposed of uniform constitution, it is much more likely that several cracks will take place, than merely a single one. Nor can there be a doubt that these parallel fissures must occur *at the same moment of time;* for, on the occurrence of one crack by itself, the tension would clearly be relieved; and the only result of a farther upheaval would be the mere widening of the first crack, which is now a *line of weakness*. Hence, then, the frequency of the phenomenon of parallel veins, and hence their necessary contemporaneity. There is no difficulty in verifying these deductions, in all the aspects and relations of mineral veins, faults,[1] &c.; and the same physical principles may be found to overrule that grand series of dislocations treated by Elie de Beaumont. It appears, then, that the contemporaneity of parallel chains crowning the same zone of upheaval, may be taken as absolute and undeniable; but unfortunately there are two considerations which prevent our absolute *application* of the principle—and in which those difficulties originate that are so emphatically indicated in De Beaumont's scheme of Systems, by the existence of separate groups, of widely different ages, but with corresponding directions. The first source of ambiguity is in the effect of successive shocks of elevation undergone by the same zone; for though these can create no new fissure, but would simply farther elevate the mountain-chains resting over the old ones, they may make, even at a late period, fissures belonging to the oldest shock, *visible for the first time*. Mr Hopkins clearly demonstrates that the cracking of every zone begins on its *lowest surface*, and proceeds upwards; and as it is perfectly conceivable that the first shock may not have completed the split in many cases, or caused it to reach the surface, it is quite consistent with theory, that subsequent shocks, while farther elevating the masses protruded through many splits, may suffice to *complete others*, and rear over them a mountain-range, not referable, in so far as dislocations of the neighbouring strata intimate, to the epoch of the first disturbance. Mr Darwin also inquires what might be the probable effect, in strengthening an old fissure, of long intervals of rest, during which the injected rock had intertwined itself with the other beds around it, and formed with them one consolidated mass? "Would not," he asks, "the crust in such case yield more readily on either flank, as I believe it must have done in the Cordillera, than along an axis composed of solidified rocks, such as granite and porphyry?" But, besides, the law only holds in the case of mountain-ranges *belonging to the same zone;* and there seems no reason to believe, considering the extent of the earth's surface, and the frequency of these oscillations, that *different zones*, with major axes corresponding in direction, may not have been acted on at different epochs. For instance, with regard to that immense area now undergoing subsidence in the coralline regions of the Pacific, is it not probable that its major axis corresponds in direction with the Eastern Alps and Himalaya; and, therefore, that such also will be the direction of its system of dislocations? It is far from improbable that the groups in De Beaumont's scheme, which correspond in direction, but differ in age, demand such a solution; and that this is the information they give us regarding the History of the Earth. Like all apparent exceptions to simple and enlarged truths, such ambiguities, while checking the universality of our application of general laws, do not invalidate the laws themselves, but only inform us better of the circumstances within which they have operated.

III. Mr Hopkins next surveyed a case in which the resulting phenomena might be supposed modified by the shape of the upraised surface; and probably his application of general principle to the specialities of the Wealden is as complete a triumph as any inquiry of this kind can be expected to accomplish in theoretical geology. The deductions having quite outrun observations, Mr Hopkins resurveyed the Wealden, with a view to the detection of its dislocations; and his theoretical chart might almost be taken as an accurate map of the country. Now, in this application of the theory, there is an achievement quite beyond any mere probable explanation of the *law of parallelism*. This law, although still the prevailing one, is interfered with and subjected to great modifications by the *shape* of the district—modifications, however, of a fixed and determinate nature, flowing from the same actions which caused the law of parallelism itself; and every *predicted* deviation of the lines of fissure or dislocation from rectilinearity and accurate parallelism, as well as every predicted new relation of the transverse lines to the longitudinal ones, agrees, with an exactness altogether remarkable, with the facts elicited by a careful scrutiny of the region.

It appears probable that a legitimate way is now opening towards the resolution of the ultimate problem of the upheaving force. The agreement of deductions from the scientific hypothesis, with actual phenomena in difficult and complex cases like that of the Wealden, goes far to establish, that all dislocations of strata, and the accompanying mountain-chains, have resulted from the upheaval of large portions of the earth's surface, by a diffused and equable energy—an energy concentrated into one point or district, only when it has produced craters of elevation. Accepting instruction from the surface of the Moon, we have certain lights also, regarding the *History* of the development of this force; for while its concentrated action, with its varied and remarkable craters, has evolved nearly all the mountain forms in that luminary—even as we find it among the almost obliterated ancient forms of the earth—its operation in raising extensive zones, now so frequently and characteristically exhibited in our own planet, has yet scarcely appeared in the Moon. The time will doubtless come, when, viewing it as a grand cosmical agency, all such specialities belonging to this yet hidden Power shall receive their solution; and we rejoice to find that Mr Hopkins, in the memoir on the whole subject he recently prepared at the request of the British Association, has carried several steps farther the investigations which he so auspiciously and so vigorously began.

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[1] It is unfortunate for our elucidation of the subject, that the space to which we are limited will admit of only a general reference to the theory of *veins* and *faults*, so fully developed in Mr Hopkins' memoir in the *Cambridge Philosophical Transactions;* nor can we do more than mention his interesting demonstration in the *Transactions of the Royal Society* for 1842, of the law first recognised through observation by Mr Phillips, that in the case of a *fault*, the displaced beds are *lowest* on that side of the fault, *towards* which the plane of the fault inclines from the vertical, in *descending*. The power of any theory to exhibit such minor laws as unexpected deductions from its general principle, constituting the strongest presumption of its truth, we shall hope that Mr Hopkins will apply the one now engaging his attention, to those more important and characteristic features of our mountain-chains, which do not flow from their *directions*. One of these is especially noticeable, viz., the fact, observable also in the case of the Lunar Apennines, Alps, Caucasus, &c.—that our great ranges are abrupt on one side—almost precipitous even, in their descent to the plains or the level of the sea; while on the other side they slope away through a long highland. There can be little doubt that this remarkable feature arises out of the manner in which the chains were upraised, and is no consequence, as has often been supposed, of subsequent modifications of their forms; and it appeared so important to Sir John Herschel and Mr Babbage, that they employed it as a fundamental characteristic in an ingenious speculation concerning the Theory of Elevation. It seemed to these eminent philosophers, that as the ocean either now washes one foot of every great mountain-range, or did so in former times (a fact necessarily resulting from the abruptness of one face of the chain), we must recognise an agent of elevation in the presence and operation of the sea; and they conceived they had discerned the mode of the requisite action, in the fact, that as the waves, by wearing down the coast and depositing its detritus at their bottom, must alter the vertical contour of the land in these localities, they will, as a natural consequence, disturb the previous position of the isothermal surfaces within the earth's crust, and produce disturbance and probably dislocations. The proposed explanation, however, is incapable of comprehending the phenomena of the problem. 1. It assumes the existence of inequalities of vertical contour, inasmuch as it assumes a line of coast; and the existence of such inequalities is precisely the feature of all our planetary bodies, which this portion of geological theory is required to explain. 2. It is not true that elevation takes place only along coast lines. The vast zone in Scandinavia that is now rising, has no relation to the sea; nor have these phenomena which Darwin recognised in the Pacific. 3. The elevating force is evidently a *planetary* one; and no *ultimate* explanation can be accepted which will not apply to other worlds than the earth. But in the Moon, though characterised by every conceivable form and mode of fracture, no ocean exists, and, in all probability, matter in the liquid state has not yet been developed on its surface.

PLATE 2

THE PHYSICAL FEATURES OF THE OLD CONTINENT
(EUROPE AND ASIA):
ITS MOUNTAINS, TABLE-LANDS, PLAINS, AND SLOPES.

The great characteristic feature in the physical relief of the old continent, Europe and Asia, is, that its masses consist of table-lands and mountains, as the new continent, America, is characterised by the extent of its plains. In the Old World, as shown in the map, the principal mountain-chains follow generally the direction of the parallels of latitude, from east to west—only the secondary chains having the direction of the meridians, from north to south; while in the New World the principal chains extend from north to south, those having an east and west direction being comparatively insignificant. (See "Notes on Some General Principles in Geology," *Physical Atlas*, page 4.) Again, in the old continent, as is evident from the direction of the water-courses, the surface slopes gradually towards the north and east, and abruptly towards the south and west; whereas, in the new continent, the long and gentle slopes are, in South America, directed towards the east, the Atlantic slope; and the short abrupt slopes towards the west, Pacific slope (see Plate 17). In North America, the long declivities face the north and south, and the more abrupt ones the east and west.

A Europe, the north-western peninsula of the great eastern continent, is characterised in the mass by two leading natural features—1st, In the north and east, the vast uninterrupted level plain or low-land; and, 2d, In the south-west, the equally connected but less extensive mountain or high-land.

I. Plains and Valleys.—The first of these divisions, the great plain, comprises nearly two-thirds of the superfices of Europe, extending from the centre of France in the west to the Ural Mountains and the Caucasus in the east; and, except in the south-west, from the Arctic Sea in the north to the Black Sea in the south. It consists chiefly of tertiary and alluvial soil, and is distinguished by its numerous lakes and extensive river-courses. This fertile region is divided by the Vistula into two unequal parts, the larger of which is the Sarmatian or east European plain, and the smaller the Germanic low-land. No mountain whatever is visible in all this wide space, and the raising of the surface of the sea little more than 1000 feet would suffice to cover nearly the whole expanse with water, and to render Scandinavia an island. On the east the plain is enclosed by the Ural mountains, and on the west by the hilly peninsula of Bretagne; on the north, towards the Baltic, it is bordered by land rising 500 or 600 feet above the general level of the plain; and in the south-east it is separated from the Black Sea by the hilly ridges of Southern Russia. The only marked elevations are the Thurmberg, 1090 feet in height, the greatest elevation between the Harz and the Ural Mountains, and the Valdai Hills, a dome-shaped elevation, 800 to 1100 feet in height, which forms the watershed between the rivers flowing north-west to the Baltic and those flowing south-east to the Caspian Sea. On the south, the plain is continued with little interruption over the broad flat steppes of the Taurida into the Crimea, where it terminates in the coast range on the south of the peninsula, the culminating point of which is the Tchatir-dagh, 5000 feet above the sea; and on the east it communicates by the Kirghiz steppes with the great plain of Northern Asia.

The minor low-lands of Europe are,—the *plain of Central France*, which is traversed by the Garonne, Seine, and Scheldt, and is connected by the valley of the Lower Aude with the shores of the Mediterranean; the *plain of the Lower Danube*, Hungary and Wallachia, which separates the mountains of south-western Europe on the south from the Carpathians on the north; the *plain of Eastern Hungary*, which is from 300 to 400 feet above the level of the sea, and is extremely fertile. The *plain of Upper Hungary* extends along the Danube from the mouth of the Gran to the mouth of the March, where it is continued by the *Marchfeld* extending beyond Vienna; *the valley of the Lower Rhine* connects the low-lands of Northern Germany with those of France, and is traversed by the Scheldt, Lower Meuse, Lower Rhine, Lippe, and Ems; *the valley of the Upper Rhine*, a narrow tract on both sides of the river, extending from the borders of Switzerland to the mouth of the Main; *the valley of the Lower Rhone*, which separates the Alps from the Cevennes Mountains; *the plains of Piedmont and Venetian Lombardy*, watered by the Po and its affluents, extending from the Alps to the Adriatic, towards which they slope, and terminate in lagoons on its shores.

II. Mountain Systems.—The mountainous or Alpine country of Europe is situated nearly in the middle space between the Equator and the North Pole, or between latitude 44° and 46° north. The mountains comprise six great systems—namely, the Hesperian, Alpine, Sardo-Corsican, Sarmatian, British, and Scandinavian. (See Plate 3, and Note, page 11.)

B Asia, separated from its north-western peninsula by the Ural Mountains and the river Volga, is, like Europe, divided into a great elevated mountainous region, and a region of valleys or plains. The first comprises two vast elevated table-lands,—1. *The table-land of Central Asia*, with the connected plateau of Eastern Siberia; and, 2. *The table-land of Iran or of Persia*,—and that of the peninsula of Asia Minor, besides the separate mountain systems of Hindostan, the table-land of the Deccan, the table-land of Arabia, the Syrian Mountains, and the Ural Mountains. The low-lands are mostly separated from each other by mountainous districts; they comprise the steppe-lands of north-western Siberia, the low-land of Turan, with the Kirghiz steppes and the Aralo-Caspian valley, the low-land of Syria and Arabia, with the plains of the Euphrates and Tigris, the plains of Hindostan, and the low-lands of northern China.

1. *The table-land of Central Asia* forms a vast upheaved region in the middle of the continent, and is crowned by the great desert called Gobi or Shamo. This table-land, according to Humboldt, who divides Central Asia into four parallel chains, separated by two meridional ones, presents, in the general form of its relief, a remarkable simplicity of structure.[1] Its southern border stretches from the Indus to the Strait of Fokien, supporting the chain of the Himalayas, which are prolonged eastwards to the Nan-ling mountains in China. The eastern border of the table-land extending from the Yang-tse-Kiang in the south, to the Amoor in the north, is separated by the Hoang-Ho into the high-lands of Southern China, the Yung-ling mountains, and those of Northern Manchooria or the Amoor mountains. The northern border is girdled by the mountain system of the Altai, while the western extension forms the high-land of Turkestan, which is crowned by the Bolor-Tagh on the table-land of Pamir, the crests of which are supposed to reach an elevation of 19,000 feet, the Muz-Tagh—Hindoo Koosh—or Indian Caucasus, extending, in the most limited sense, from the Upper Indus westward to the Bamian Pass, but being connected on the east with the Kuen-lun, and west with the Huzareh Mountains in Afghanistan, it may be traced across Persia, to the Taurus in Asia Minor on the west, and to the frontier of China on the east, forming in this view "the most striking geological phenomenon amongst all the mountain ranges of the Old World," the peaks of which vary from 10,000 to 19,000 feet above the sea. On the north the Hindoo Koosh is connected with the table-land of Pamir. The chief summit of the Hindoo Koosh proper, is supposed to be 19,000 or 20,000 feet above the sea.

The table-land within the boundaries indicated is traversed by two mountain systems.

1. (I.) *The Thian-shan*, or Celestial Mountains, with the Bogdo Oola, or Holy Mountain, and the volcanoes of Pee-shan and Ho-tsou; and (II.) *the Kuen-lun*, which, with the mountains of the north and south borders, encloses four great plateaus: 1, Between the Kuen-lun, the Himalaya and its northern slopes, the table-land of Tibet; 2, Between the Kuen-lun and the Thian-shan, the plateau of Upper Tartary with the elevated terraces of Tangul and Sifan, and the desert Shamo or Gobi—which desert is the basin of a former vast inland fresh-water lake, and is comprised in the great rainless zone of Central Asia; 3, Between the Thian-shan and the Altai, the plateau of Dzungaria or Thian-shan-pee-loo; and, 4, The eastern slope forming the plateau of Mongolia, which includes the northern portion of the Gobi.

2. *The Mountain System of the Altai* extends itself as an Alpine girdle from the sources of the Aldan in the east to the Issi-kul lake in the west, separating Mongolia and Dzungaria in the south from Siberia in the north. It is divided into three natural groups, the easternmost of which extends west to the Selenga and Lake Baikal, the middle one thence to the Dzaisang lake and the Irtish, and the westernmost to Issi-kul and the Tschai lake. The first group comprises the great Khiang-khan, on the western chain of the Khingan-Oula, with the elevated mountain-knot of Kentei-khan and the Alpine land of Dauria with the Tschokindo mountains, 7000 to 8000 feet above the sea. North-east of the last, and probably a continuation of the Daurian mountains, extends the Yablonoi Krebet, a higher mountain range than the Aldan mountains, which sends out many branches under the name of the Udskoi and Stanovoi Krebet mountains, from the sources of the Aldan to the East Cape. The middle group embraces the chain of the Tangnou mountains with their ramifications, and the great and little Altai. The western group is formed by the Dzungarian mountains, and in the extreme west merges into the Kirghiz mountains.

3. *The Table-land of Iran* is connected with that of Central Asia by the Hindoo Koosh mountains, by which it is bounded on the north-east; its average height is from 2500 to 3500 feet above the sea: it sinks to a somewhat lower level in the plateau of Khorasan, but in the north it rises in the Elburz mountains to 14,695 feet in the volcano of Demavend; westwards it joins the plateau of Armenia. On the east it is bordered by the Suliman range west of the Indus, which in the summit called Takht-i-Suliman ("Throne of Solomon") has an elevation of 11,000 feet. This mountain mass, usually described as a single chain, is composed of a series of ranges, nearly perpendicular to the Indus, and separated from each other by considerable rivers. From the Suliman mountains the table-land sinks abruptly towards the plains of the Indus. The *Khyber mountains* connect the Suliman mountains with the southernmost and lowest range of the Hindoo Koosh, the Sufeid Koh, and the Salt range. Jatara, the highest point of this range, is 3500 feet above the plains of Peshawur, or 4800 feet above the sea. The Khyber Pass, called the "Key of Afghanistan," is the principal entrance to India on the north, as the Bolan Pass is on the south of the country.

The south and west borders of the plateau extend along the coast of the Persian Gulf and the Arabian Sea to the plateau of Armenia, forming a series of mountain-chains and terrace slopes connected with the Zagros mountains in Kurdistan. The plateau of Iran is comprised in that rainless and sterile zone which stretches over Northern Africa and Arabia into Central Asia and Mongolia, and hence all the eastern part of Persia is a vast salt desert, destitute of rivers.

4. *The Plateau of Armenia*, which extends between the Caspian and the Black Seas and the Gulf of Scanderoon, is about 7000 feet above the level of the sea: upon it rises the ancient extinct volcanic mountain of Ararat, the culminating point of Western Asia; the highest peak of which, the Agri-dagh, is 17,212 feet above the sea; and this, as well as the lower peak, Allah-dagh, surpasses the limits of perpetual snow. The high-lands extending north between the rivers Kur and Rion connect the plateau of Armenia with the Caucasus, which in the middle region has a peculiarly Alpine character. Its culminating point is Mount Elburz, 18,493 feet above the sea, and its next highest point is Mount Kazbek, 16,523 feet in elevation. The chain terminates on the east in the peninsula of Apsheron in the Caspian Sea, the soil of which is impregnated with sulphur and inflammable gas. It is famous as the site of the "sacred flame" of Baku, venerated by the fire-worshippers of Asia.

5. *The Plateau of Asia Minor*, which is the western prolongation of the plateau of Armenia, presents in its conformation a mountainous mass, with a mean elevation of about 3280 feet, the centre of which is a lower plateau, averaging about 2800 feet above the sea. This plateau contains the greater portion of plain surface in the peninsula. It has a hard rocky soil, and is interspersed with numerous salt lakes, separated by fertile valleys, the rest being a conglomeration of mountains extending in a north-west and south-east direction. The most elevated of these are in the south—the Taurus range, 9800 feet, and Mount Argæus, 13,000 feet above the sea. Near the north coast are Mount Olympus, 6332 feet above the sea, and Mounts Ida and Gargarus. Anti-Taurus is composed of two parallel ramparts, the highest of which, Argish Tagh, is 13,000 feet above the sea: north of these is the Euxine range, bordering the Black Sea.

6. *The Table-land of Arabia* (Jezirет-el-Arab).—A large portion of this vast country is traversed by the great rainless belt of the Old World, and is consequently an arid desert. Its centre appears in some places to attain an elevation of 8000 feet. Mountain ranges in various directions traverse the central plateau, and the south-east range rises to 5000 feet above the sea. The climate is the driest in the known world, but wherever the soil is irrigated, it produces a luxurious vegetation. All north of the Hedjaz to near the Euphrates, is a continuous plain of moving sand. On the east and south, the surface slopes in terraces, and the coasts are mostly high and steep.

7. *The Mountains of Syria and Palestine.*—This group forms the connecting link between the Arabian and the Taurus mountains. The west or coast portion of the country is mountainous, and the east chiefly an elevated plain. The mountain-chains range mostly in the direction of north and south. Jebel-el-Makmel, the highest point of Lebanon (*Libanus*), has an elevation of 12,000 feet above the sea. In Mount Hermon, Anti-Lebanon has an elevation of 10,000 feet above the sea. Anti-Lebanon, in its extension towards the south, opens up to enclose the valley of the Dead Sea and the Wady-el-Ghor, to the head of the Gulf of Akaba. In this remarkable depression the surface of the Dead Sea is 1312 feet below the level of the Mediterranean. (See Section at foot of Plate.)

8. *The Ural Mountains*, the central ridge of which, in the direction of north and south, separates Europe from Asia, consists of several round-backed plateau-shaped masses, mostly of little elevation. The Urals extend in the widest sense from Novaia Zemlia to the high ground between the Caspian and Aral Seas. A western chain trending north-north-west from the middle ridge, in latitude 62°, has an elevation of 200 to 600 feet. The Ural Mountains are composed of crystalline and slaty rocks, and are rich in gold and other metals: the highest point is 5397 feet above the sea.

9. *The Mountain System of Hindostan.*—The physical features of this great peninsula, which are extremely diversified, comprise a central table-land, a vast circumvallation of mountains, and a series of low plains. On the north the peninsula is bounded by the Himalayas, which separate it from the table-land of Tibet. On the west the chain of the *Western Ghauts* runs nearly parallel to the shore from Gujerat to Ceylon. The northern limit of the Western Ghauts is formed by the valley of the Taptee river, whence the chain rises in height as it proceeds southwards, till at Mahabuleshwar, lat. 18° N., long. 73° 40′ E., it is 4700 feet in elevation. Here the western declivity is abrupt, and its base depressed nearly to the level of the sea. The eastern declivity is undulating and rugged, and slopes gradually to the plains of Hyderabad. The mountains are of primary formation, enclosed by strata of more recent origin, which has been broken up by outbursts of volcanic rocks, forming terraces, with numerous chasms and breaks, which give access to the high-lands. From these ghauts or passes the name of the range has been derived. The chief elevations between lat. 18° and 19° N. are Poorundhur 4472 feet, Singhur 4162 feet, and Hurreechundurghur 3894 feet above the sea. About lat. 15° the slopes are rounded, and the height of the range is lowered to about 1000 feet above the sea. Further to the south the elevation again increases till, at about lat. 12°, Bonasson Hill is estimated at 7000 feet, Tandiamnole 5781 feet, and Pupugiri 5682 feet above the sea. South of these groups the Western Ghauts join the Neilgherry hills by the *Nedimula* range forming the western buttress of the Neilgherry table-land to lat. 11° 15′, long. 76° 25′, where it rises into the Kunda Mountains; and 25 miles further south the range ends abruptly in the lofty precipices which form the northern side of the Palghat valley, a vast depression, extending east and west, with a breadth of 20 miles, and forming an easy communication between the Carnatic and Malabar. This valley is bounded on the south by the mountains which terminate in Cape Comorin, 500 feet above the sea. The length of the range is about 800 miles. Stretching east-north-eastwards from the Ghauts, the *Vindhya* range and the *Satpoora* range of hills enclose the basins of the Taptee and Nerbudda rivers. The Vindhya mountains form the northern boundary of the valley of the Nerbudda, extending from Gujerat on the west to the basin of the Ganges on the east, between lat. 22° and 25° N., connecting the northern extremities of the Eastern and Western Ghauts. The Satpoora hills divide the valley of the Taptee from that of the Nerbudda, and extend between the parallels of lat. 21° and 22° N., from long. 73° 40′ to 78° E., where they merge into the Vindhya range. They are of volcanic formation, and have bold outlines with several lofty peaks, estimated at from 1200 to 2000 feet above the sea. From the western extremity of the Vindhya range the *Aravulli* range of mountains extends in a N.N.E. direction from about lat. 22° 40′ N., long. 74° E. to lat. 26° 50′ N., long. 75° E. At its southern extremity the range is low and little marked: it rises towards the centre, and again declines on the north towards the rocky ranges of Delhi. The rocks are of primitive formation, and abound in tin, iron, silver, copper, and antimony. The highest point is Mount Aboo, 5000 feet above the sea. On the eastern side of the peninsula the *Eastern Ghauts* form an irregular structure much lower than the western range. The chain rises near Balasore, in about the same latitude as the Western Ghauts: it proceeds south-westward to the west of Ganjam, and thence to Naggery Nose, 56 miles north-west of Madras, where it forms a junction with a range which crosses the peninsula in a south-western direction, and joins the Western Ghauts north of the gap of Paulghautcherry. South of this junction the Eastern Ghauts extend in detached hills to where the Eastern and Western Ghauts are united, within 20 miles of Cape Comorin. The mean elevation of the range is about 1500 feet. Sloping gently from the inner side of these last-named mountain-barriers is the *table-land of the Deccan*, resting on the high lands of Malwa on the north, and extending south and east till it terminates in the mountain spur, which stretches from the Neilgherries towards Madras. The mean elevation of the table-land is from 1500 to 2500 feet above the level of the sea, and its surface is sprinkled over with isolated conical hills, rising about 2000 feet above the plateau, or 4000 feet above the ocean. The *Neilgherry* hills, which constitute the junction between the eastern and western Ghauts, rise in the highest peak to 8760 feet, while several of the other peaks have an elevation of 6000 to 7000 feet above the sea. This group forms an elevated table-land rising to a centre; it is situated between lat. 11° 10′ and 11° 35′ N., long. 76° 30′ and 77° 10′ E.; greatest length from south-west to north-east 40 miles, breadth 15 miles. On the north it is connected by a narrow neck with the table-land of Mysore, above which it rises to about 3500 feet, and, except for its connection with the Western Ghauts, the group would be completely isolated. The mountains rise from the plain of Coimbatore in a vast precipitous mass, to a central peak forming the highest known land in India south of the Himalaya. The principal peaks are Dodabetta, 8760 feet; Kudiakad, 8502 feet; Bevoybetta, 8488 feet; Murkurti Peak, 8402 feet; Davursolabetta, 8380 feet; Kundah Peak, 8353 feet; Kundamoya, 7816 feet; Ootacamund, 7361 feet; Tamburbetta, 7292 feet; Hokulbetta, 7267 feet; Urbetta, 6915 feet; Kodanad, 6815 feet; Davebetta, 6571 feet; Kotagiri, 6571 feet; Kundabetta, 6555 feet; Dimhutty, 6330 feet; and Coonoor, 5886 feet. The hills are of a rounded form, and covered with close turf. The rocks comprise granite, syenite, hornblende, quartz, felspar, and gneiss. Iron is the principal mineral. The Neilgherries are celebrated for the eminent salubrity of their climate.

10. *The Himalayas*—"the abode of snow"—the Imaus of the ancients.—The mass of mountains which surround the Mansarowar Lake may be regarded as constituting the true centre of the Himalaya. From this point the Gogra, Sutlej, Indus, and Yaru rivers all flow to the Indian side of Asia, and from it also four mountain-chains diverge:—1. The Eastern Himalaya, whose axis runs north of Nepaul, Sikkim, and Bhotan, to the bend of the Yaru, the valley of which it divides from the plains of India. 2. The North-west Himalaya, which separates the valley of the Indus from the plains of India: behind these, and probably parallel with them, lie two other chains. 3. The Kuen-lun or Karakorum chain, dividing the Indus from the Yarkand river. 4. The chain of the Yaru, of which nothing is known.[2] All the waters from the two first of these chains flow into the Indian Ocean, as do those from the southern faces of the third and fourth. Those from the north side of the Kuen-lun, and of the chain north of the Yaru, flow into the great valley of Lake Lhop, which was probably at one time continuous with the Amoor river.

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[1] According to more recent travellers, the mountain mass of Pamir or Bolor, between the sources of the Oxus and those of the Yarkand rivers, is regarded as a centre from which spring the three greatest mountain systems of Asia. 1. A great chain, which follows a north-eastern direction as far as Behring Strait, separating all the rivers of Siberia from those which flow into the Pacific Ocean; 2. The Hindoo Koosh, continued westwards through Persia and Armenia into the Taurus range in Asia Minor; and, 3. The Muz-tagh, or Karakorum, which probably extends due east into China south of the Hoang-ho, and which, south of the Mansarowar lake, merges into the ranges forming the Himalaya.

[2] This view of the mountain systems of the Himalaya and of Central Asia is that adopted by the recent travellers, Dr Thomson and Dr Hooker. It is considered more in accordance with nature, and with what is known of the geography of the country, and of the nature of mountain-chains, than that of the illustrious Humboldt, explained in his "Asie Centrale."

The Himalaya Mountains extend over twenty-two degrees of longitude,—from 73° 23' to 95° 23' east, or from the great bend of the Indus to that of the Brahmaputra: their mean breadth is computed at 150 miles. The Himalaya is not, as has been represented, an individual mountain-chain, but a group of snowy peaks, widely separated from each other, the spurs of a much higher snowless region behind. Their mean elevation is probably 18,000 to 20,000 feet. The range from west to east comprises the following mountain peaks, passes, and river-basins:—1. The Peak of Jamnoutri, 25,669 feet; 2. The Peak of Nanda-Devi, 25,749 feet; 3. Dhawalagiri, 27,600 feet; 4. The Peak of Gossain-than, 24,700 feet; 5. The Peak of Kinchinjunga, 28,178 feet, east of which is the Lacheh Pass into Tibet; 6. Donkia Mountain, 23,176 feet; 7. Chumulari, 23,929 feet; and 8. Zwillinge, or the Twins, 21,600 feet. These mountain-knots enclose the upper or Alpine basins of the rivers Ganges; the Karnali, which forms the Takla-Khar Pass; the Gandak, at the head of one of the sources of which is the Mustung Pass, and of another the Kerung Pass; the Cosi, on the head streams of which are the Kuti Pass, the Hatia Pass, and the Wullung Pass; the Tishta, which has its source in Lake Cholamu, in the table-land of Tibet; the Monas, which joins the Brahmaputra N. of the Garrow hills; and part of the basin of the Subhansri, another tributary of the Brahmaputra. These river-basins are separated by meridional chains, extending in a southerly direction from each of the mountain-knots above described.

The range of the snowy Himalaya is marked on the map by the darkest line of parallel ridges forming the watershed between Tibet and India. On the south this mountain region terminates by a low ridge of land sloping southwards to the plain of India. The entire surface of the Himalaya is divided into three distinct regions: 1. The lower region, from the level of the plain to 4000 feet above the sea; 2. The middle region, 4000 to 10,000 feet above the sea; and, 3. The upper region, from 10,000 to 16,000 feet above the sea.[1] The geological formation of the upper region is granite and gneiss; of the middle region, gneiss and slate; and of the lower region, sandstone and diluvial detritus. These three regions present the most marked peculiarities of structure. In crossing from the plains of India to Tibet there is, first, the green "Tarai," so unlike the arid plains of Upper India; next the great belt of Saulwood; and then the Dhuns or Marais, in the sandstone region, separated from the region of wood by a low mountain-range. From the small section (A) it will be seen that the Tarai sinks below the level of the plain, that the wooded region rises gradually above it, and that the region of the Dhuns extends upwards to the foot of the true mountains.

The Tarai is an open plain, covered with grass, and noted for its insalubrity, which arises from its extraordinary dampness and its numerous marshes. The "Bhever," or wooded, region is equally unhealthy, but it is as peculiar for its aridity as the other is for its moisture, owing to the porous nature of its soil. The sandstone belt, 300 to 400 feet in elevation, is rich in fossils; it is 3000 feet above the sea, or 2000 feet above the plain. The "Dhuns" have a climate as dry and unhealthy as the former; they are from 5 to 10 miles broad, 2500 feet above the sea, and 1500 feet above the plain. On the north this immense mountain mass is immediately connected with the elevated *table-land of Tibet,* the whole surface of which, in as far as yet ascertained, is traversed in every direction by mountain ranges in all respects similar to those which constitute the Himalaya. The northern boundary of Tibet is formed by the snowy chain of the Kuen-lun mountains, of which very little is known. The table-land of Tibet appears to be characterised by a striking uniformity of climate and natural productions. It is separated naturally into two great divisions, about the region occupied by the lakes of Manasarowar and Rawan Rhad, in the eastmost of which the drainage flows towards the Sanpu or Brahmaputra. Of this portion very little is known. The other, or western division, is drained chiefly by the Indus and its tributaries. This portion has been frequently visited by Europeans. The mean height of the table-land is estimated at 16,000 feet; the minor mountain ranges being 17,000 to 18,000 feet; and the principal ranges, 19,000 feet above the level of the sea. Far from being a plain, as was erroneously supposed, it appears that the mountains on the southern border of Tibet, at least to the west of the Sutlej, where alone they are well known, are, in many peaks of the interior, even more lofty than any of those near the plains of India.[2] Glaciers are found in all the mountains of the Himalaya and Western Tibet, wherever they attain an elevation above the snow line (see Geographical Distribution of Glaciers, p. 33). As there explained, the Himalaya rises 9000 feet above this line on the southern side, and 12,000 feet on the northern or Tibetan side. Kinchinjunga is the highest ascertained mountain-knot of the Himalaya, and is presumed to be the culminating point of the globe. It rises in three heads of nearly equal height, forming a line running north-west.[3] It exposes many white and grey rocks, bare of snow, and the round-knobbed form of its summit suggests a granite formation.[4] The passes of the Himalaya are from 16,000 to 19,000 feet above the level of the sea.

In Eastern India, the *Ramgurh* hills in Bengal cover a considerable extent of surface, forming groups or detached plateaus of moderate elevation, separated by gentle depressions. The most extensive and elevated of these plateaus is that of Hazareebagh, about 1800 feet above the sea. Many of the hills are of primitive formation, but others of a later date abound in coal and iron.

11. The *Mountains of Assam* constitute the borders of the country on the north, south, and east; they are of great but unknown elevation. In the interior the province is described as comprising an immense plain, covered with groups of hills rising abruptly from the general elevation. The valley is traversed by the Brahmaputra, which, by its inundations, has raised a rich and widely extended alluvial soil. Little is known of the geology of Assam; the mountains on the north of the plain are described as consisting of primitive limestone, granite, serpentine, and porphyry, and those on the south are said to be mostly of gneiss and stratified granite. Coal has been discovered in many places on the north of the Brahmaputra. Iron ore is found, and gold dust is washed down by the rivers. Between the Assam mountains and Sylhet the *Cossyah* or *Garrow Hills* cover a large area, but are of no great elevation. They were supposed to be rich in minerals, but from a recent geological survey it appears that neither iron nor coal are abundant.

12. *The Mountains of Ceylon.*—The central and southern parts of the island are elevated and mountainous, Adam's Peak being 7420 feet, and Pendrotallagalla Mountain 8280 feet above the sea. The eastern shores are in many places bold and rocky, while the western shores are uniformly low, and indented with bays and inlets. The chief geological features are gneiss in the south, lime and sandstone in the level parts of the north, and dolomite in the interior. The summit of Adam's Peak is of hornblende. The principal minerals are iron, manganese, plumbago, nitre in caves, and salt.

II. The Plains and Depressions of Asia comprise a large portion of true steppes and deserts, interspersed with the richest and most fertile valleys. The most important are—

1. *The Chinese Lowland,* which consists of a district of pure alluvium. It is situated between latitude 30° 15' and 35° north, and extends from the shores of the Yellow Sea to a great distance inland, covering an area of about 80,000 square miles, the greater part of which is destitute even of a pebble or a grain of sand. This extremely fertile tract comprises the deltas of the Yang-tse-Kiang, the Hoang-Ho, and other rivers north and south of Pekin.

2. *The Plains of Further India,* in Cambodia and Siam, comprise the rich valleys on the west of the Gulf of Tonquin and those of the rivers Mekong, Menam, Saluen, and Irrawady. Of these regions very little is known.

3. *The Plains of Hindostan.*—The Ganges, which is not separated by any prominent watershed from the Indus, is, at Benares, only 270 feet above the sea. Its valley forms a wide hilly alluvial plain, which, in Bengal, opens out, and is traversed by numerous smaller streams. Where it enters the Bay of Bengal the Ganges forms a cluster of small marshy islands, the result of the deposition of soil washed down by the river during its periodical inundations. This district is called the *Sunderbunds.*

4. *The Valley of the Indus,* in the Punjab, is an alluvial plain, extending for several hundred miles without any eminence except the salt hills near the base of the Himalaya. The soil of this plain is generally sandy and barren, but it is interspersed with fertile spots, and is abundantly supplied with the means of irrigation. In the north of Scinde the valley is remarkably fertile in the alluvial district extending on both sides of the Indus; but in the lower part, an extensive alluvial tract, being deserted by the river, is now a desert, and the country of the delta, overflowed by the tide, is a barren, unprofitable waste of sand called the *Thur.* On the east of this is the remarkable depression termed the *Runn of Cutch,* which, within a comparatively recent period, has evidently been subjected to a succession of upheavals and descents. The sea at one time, probably, swept over the present Runn, and extended far beyond its boundaries; and a series of positions along the old sea margin indicate, by their names, the ports, custom-houses, and other places along the shore. Ruins are now found 15 feet below the surface of the soil, which must have been sunk beneath the waves to this depth, and brought to their present position by a fresh upheaval. The Runn was to a great extent submerged by an earthquake on the 16th June 1819, and it is now divided into two portions, one of which is a salt lake and the other a salt-water marsh. To the north of the Runn are two remarkable hollows at some distance from each other, termed the *Null* and the *Boke.* These appear to be the result of volcanic agency. They contain salt-water, receiving supplies of fresh water from rivulets, but discharging none. Near the centre of the Deccan the basin of Lake Loonar forms a depression about 500 feet below the adjoining country. It appears to be the crater of an extinct volcano, as lava is found near it in great abundance. It contains water nearly saturated with subcarbonate of soda.

5. *The Valley of Kashmir* consists of an alluvial plain, about 50 miles long, 10 or 12 miles wide, and 5300 feet above the sea. It is the valley of the river Behat, and the bed of a former lake. The valley is completely surrounded by a girdle of snowy mountains, and is separated by snowy ranges from the valley of the Chenab on the south, and by the main axis of the Himalaya, from the basin of the Indus, on the north. On the south side of the valley several passes, 10,000 to 14,000 feet above the sea, lead to the plains of India.

6. *The Low-land of Turan and Bucharia* extends from the table-land of Iran on the south to the Ural Mountains, and a western branch of the Altai on the north. Its lower portion comprises the great depression of the Caspian and Aral Seas, forming the basin of the continental streams (see Plate 16, page 55). This immense area, the greatest horizontal hollow on the surface of the globe, is apparently the basin of a former inland sea,—the present level of the Caspian being 83 feet below that of the Black Sea.

7. *The Low-lands of Syria and Arabia* are, in the southern part, dry and stony deserts, almost destitute of water; but in the north, near the lower courses of the Euphrates and Tigris, they are rich and fertile. In the north of Palestine the Valley of Bekka is a fertile and well-watered tract, extending between the ranges of Lebanon and Anti-Lebanon; and in the south the *Dead Sea* presents the deepest and most remarkable depression on the globe, the surface of its waters being 1312 feet below those of the Mediterranean. The Dead Sea is supposed to have been at one time connected with the Gulf of Akaba, from which it is now separated by the Wady Araba, a sloping valley, the highest part of which, of unascertained elevation, forms the barrier between them. The bottom of the Dead Sea consists of two submerged plains, the lowest of which is about 1300 feet below the surface.

8. *The Plains and Steppes of Siberia.*—This region, extending from the Ural Mountains on the west, to the Pacific Ocean and Behring Strait on the east, slopes northwards from the base of the Altai Mountains on the south, to the Frozen Ocean on the north. In the southern regions the surface is covered with forests, interspersed with many fertile valleys. In the west the steppes are flat or undulating, without any prominent eminence, while all the northern portion is a trackless wilderness, with numerous small salt lakes and marshy flats, called *Tundras,* the soil of which is frozen to a depth of several hundred feet during a great part of the year.

III. ON THE MEAN HEIGHT OF THE CONTINENTS.

This subject was first examined philosophically by Humboldt. He was led to the investigation from a discovery of the evident errors of Laplace, who, from theoretical considerations regarding the form of the globe, concluded that the mean depth of the sea must be a measure corresponding to that of the mean elevation of the continents, which he estimated at 1000 metres, or 3280 feet. Humboldt considered this inquiry all the more necessary, since, from the imposing elevation of mountain chains, they exercise a far more striking effect on the imagination and the senses than the masses of the continents and table-lands, although their effect in elevating the superfices is comparatively insignificant. This is evident from the fact that the elevation of the highest summits yet known, above the level of the sea, amounts in measurement to only about the five thousandth part of the circumference of the globe, or the sixteen hundredth part of its diameter. Taking, for example, the chain of the Pyrenees, the mean height and horizontal area of which have been accurately measured, it is found by calculation that, if the entire mass of these mountains were pulverised and spread equally over France, the surface of that country would by that means be raised only to the extent of 115 feet; or if the mountain mass of which the chain of the Alps is composed—the base of which is nearly four times greater than that of the Pyrenees—were similarly abraded and distributed over the whole extent of Europe, its present surface would not thereby be raised more than 22 feet; while, on the contrary, the Iberian peninsula—Spain and Portugal—with its compact plateau mass of nearly 2000 feet of elevation, would, if so levelled, produce an effect equivalent to 76 feet, or four times more in proportion than the system of the Alps. It thus appears that the mean height of continents depends far less on the culminating points or domes of the great mountain-chains than on the general configuration of the table-lands and elevated plains. The effect of the Alps in elevating the surface of Europe is compensated by the great plain in the north, and that of the colossal masses of Asia is diminished by the low elevation of a large portion of the continent, the steppes or plains of Siberia, which, with an area greater by one-third than the whole of Europe, has a normal height of not more than 225 feet above the level of the sea. The steppes of the Gobi cover a region twice as large as the whole surface of Germany, and would raise the centre of gravity of Asia to the extent of 128 feet; while the Himalaya Mountains and the Kuen-lun, with the table-land of Tibet, by which they are connected, would produce an elevating effect on the whole of Asia amounting to 358 feet. The result of a laborious course of investigation leads to the assumption, that the centre of gravity of the land, or the mean height of the continents (Africa being excepted) above the present level of the sea, is in—

	Feet above the sea.		Feet above the sea.
Asia, ...	1151	North America, ...	748
South America, ...	1132	Europe, ...	671

(See the comparison represented graphically in the diagram at foot of the Plate).

IV. UPHEAVAL OF THE ISLAND OF REGUAIN.

In the Old World three localities have long been known on which the phenomena of upheaving, by subterranean force, was visible. 1. Scandinavia, and other countries of the Baltic generally; 2. The west coast of Italy; and, 3. The shores of the Gulf of Cutch, in the west of India. A fourth territory of upheaving became known in 1840, by means of the nautical surveys of the brig Childers, on the west coast of Aracan. From these it appears that the Island of Reguain, or Flat Island, as well as all the other islets and rocks on that part of the coast of Aracan, is undergoing a process of upheaval. The whole coast, from Akyab to Cape Negrais, is indented by deep and narrow gulfs, similar to the fiords of Scandinavia. This district lies within the prolongation of the great volcanic band of the Sunda Islands, which extends from Java to Sumatra, Barren Island, and Narcondam; and indeed all the islands on the coast of Aracan bear evident marks of subterranean fire. In the Island of Cheduba alone (lat. 18° 51' N., long. 93° 28' E.), there are two mud volcanoes, which rise to a height of from 100 to 200 feet. This line of upheaval is in the direction of N.W. by N. to S.E. by S. It is about 100 geographical miles in length, and varies in breadth from 20 miles to a very narrow stripe of islets and rocks. The upheaval has been greatest in the middle of the line. At the Terribles it was 13 feet; at different parts of the north-west reefs of Cheduba, 22 feet; at the north point of the island, 16 feet; at the middle, on the west coast, 13 feet; at the south end, 12 feet; and in the islands south of Cheduba to Foul Island, from 9 to 12 feet. The first symptoms of upheaval appeared about the year 1750 or 1760, on the occurrence of a great earthquake, by which the sea was driven over the land, and the effects of which were felt as far as the city of Ava. An earthquake is said to have occurred 100 years earlier, and the inhabitants believe that a similar phenomenon occurs every century. The different portions of upheaval in the Island of Reguain are indicated by colours on the plan on left margin of the map. On this islet three periods of upheaval are distinguished. The line coloured green shows the beach of the original island; *V,* a volcano near its centre, about 90 feet above the sea. The yellow line represents the beach of the land subsequently raised. This eruption commenced northward, at the points *a b,* and southward of the point *v.p.* of the first beach. *v.p.* is a very small volcanic mount, from which issues a quantity of petroleum. The outer portion of the island was raised about the year 1760. *c* was a small islet before the last eruption. The dotted line which surrounds it, and the one farther southward, were apparently sand-banks. *w* denotes a well; *d,* salt marshes; *e,* former streamlets. The numerous marks + + denote masses of coral and of other rock, which completely cover the outer formation. The second formation has but a few here and there, and the original island is perfectly clear of them, with the exception of a slight sprinkling near the streamlet at its northern point. The land last raised is quite uncultivated; the remainder of the island is one large paddy field: and *f* is one of several rocks on the last-raised land, which exhibits a water-line of the same height as that of the second formation. The whole island consists of three nearly perfect levels, differing only by 6 or 8 feet in height, the inner one having at its centre a volcano about 90 feet above the sea. The water is very shoal to the northward, and also on the eastern side of Reguain. *L,* landing-place.

V. EXPLANATION OF THE GEOLOGICAL MAP OF JAVA. BY DR THOMAS HORSFIELD.

(a) Volcanic Region.—The volcanoes, whether in a state of activity or extinct, are marked thus **o**. Dr Horsfield gives the following information:—Gagak and Paduha; crater in a state of partial activity. Salak; crater, last eruption 1761. Tankuban Prahu; crater discharging sulphureous vapours from various apertures. From Tilo to Chirukai, extinct volcanoes. Papandayung; the crater fell in in 1772. Guntur; crater, last eruption about 1807. Manglayang and Maruyung, extinct volcanoes. Chermai; crater, last eruption in 1805. Talaga Bodas; crater, with a lake with water. Ungarang; crater extinct. Lawu; crater discharging sulphureous vapours. Klut; crater exploded in 1785. Arjuna; crater discharging smoke. Dasar; crater, last eruption in 1804. Lamongan; crater exploded in 1806. Ringgit; remains of the crater, which fell in in 1586, according to Valentyn. Tashem; crater, last eruption in 1796.

(b) Secondary Volcanoes.—1. Extensive district of secondary volcanoes, mixed with hills of limestone, especially near the sea, where the limestone rocks are piled up to great heights; basis basalt with breccia in the beds of rivers; also porphyry, jasper, cornelian, agate, obsidian. In some places quartz appearing in rock-crystals, prasem or amethyst, rarely siliceous petrifaction. 2. Mixed calcareous rock-sand ridges imposed upon or alternating with volcanic ridges.

(c) In the Calcareous Region, which is coloured light green, the District of Surabaya (3) consists of alluvium resting on a calcareous basis.

(d) Valley, the basis of which is gravel in irregular concretions, or in immense strata, frequently caked together as sandstone in a flat or cubical form, called Padas by the Javans.

(e) Alluvium.—4. Near the sea immense piles of calcareous rocks with large excavations. 5. Low sandy district.

- *H.* Hot well.
- *M.* Mineral well.
- *N.* Well of naphtha.
- *S.* Salt well.
- Wells of water impregnated with fixed air.

6. Secondary volcanic ridge.
7. Extremity of a stratified volcanic ridge.
8. Wells of fresh water in the sea.
9. Abrupt piles of breccia basalt.

•10. Calcareous well.

▵ 11. Volcanic ebullition.

The trees show the line of the teak forests.

VI. Volcanic Kingdom of Luzon.—This, the most northern and the largest of the Philippine Islands, is situated between latitude 12° 30' and 18° 45' north, and longitude 119 45' and 124° 15' east. Its surface is mostly mountainous, the northern part being composed of granite and recent volcanic rocks, with secondary and tertiary deposits and coal. The southern part, in the district called the Camarines, is almost entirely volcanic. On this Map the volcanoes are represented on a larger scale than was possible on the Map of Volcanic Phenomena. (See Plate 10.)

VII. SECTIONS.

The lines of the sections at the foot of the Plate have been chosen with a view to the representation of some of the more striking features in the physical relief of the Old World. That on the line A.B., from west to east, between the parallels of 40° and 50°, shows the gradual rise of the plain of France and the mountains on its eastern border, terminating in the Jura range; the table-land of the Jura, and the sudden rise of the masses comprising the Swiss Alps, their declension thence to the plains of Hungary, the rise of the surface again to the Carpathians on the east; and the depression of the Caspian below the level of the Black Sea. Section C.D., about the meridian of 13° east, starting from the Arctic Ocean in the north, cuts the great plateau of Scandinavia, slopes gently by the table-land of Gothia to the Baltic Sea; thence it crosses the great plain of Northern Europe, and rises from Dessau to the Erz-Gebirge; rising to its highest point in the eastern Alps, it sinks abruptly to the Adriatic, whence it again rises in the Apennines, and declines gently to the Mediterranean. This section shows the snow-line ascending above the surface, in a direction from north to south. The next section shows, on a large scale, the limited portion of Palestine which comprises the hollow formed by the Jordan, and the remarkable depression of the Dead Sea below the Mediterranean. The section across the Himalaya shows the rise of the surface from Cape Comorin, at the southern extremity of the peninsula of Hindostan, the hollow of the Palghat valley, the table-land of the Deccan, supported by the Neilgherries on the south, and the Vindhya mountains on the north, and the depression of the plain of India, succeeded by the stupendous elevations of the Himalaya mountains. Between the Himalayas and the Kuen-Lun mountains is the high table-land of Tibet; beyond the Kuen-Lun the surface falls to the plains of Upper Tartary, and thence the ground slopes northwards to the steppes of Siberia.

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[1] See paper by B. H. Hodgson, Esq. Journal Asiat. Soc. of Bengal, 1849. Berghaus Geog. Jahrbuch, 1851.

[2] Dr Thomson's Western Himalaya.

[3] The name of this celebrated mountain is spelled Kanchainjunga, Kinchinjunga, Kinchingunga, or Kunchinjunga, by different travellers. The measurements, ascertained from three different trigonometrical stations on the plain, are respectively, 28,125.7, 28,162.8, and 28,192.5 feet; and from four stations in the Sub-Himalaya, 28,177.4, 28,183.0, 28,162.5, and 28,212.8 feet. The mean result, as stated above, is 28,178 feet.

[4] Hooker's Himalayan Journal.

PLATE 3

ON THE MOUNTAIN SYSTEMS OF EUROPE,

CONSTRUCTED ON THE BASIS OF

NORMAL CONTOURS, OR LINES OF EQUAL ALTITUDE ABOVE THE MEAN LEVEL OF THE SEA.

Hypsometry only began to be pursued as an important branch of inquiry about the beginning of the nineteenth century, when Ramond and Laplace had completed their barometrical formulæ, and when more accurate principles were applied to the construction of the mountain barometer.

Till within a recent period, the measurements of heights of the great mountain systems of Europe scarcely amounted to a few hundreds; but now, through the labours of Olsen and Bruguière and their numerous followers, materials have been accumulated sufficient for the construction of an orographic plan, exhibiting at one view the mountains, table-lands, hills, and valleys of this quarter of the globe. The principle on which this map is constructed is that of contour lines, or lines of equal elevation above the mean level of the sea, each of which represents a definite interval of space beyond that which precedes it. Thus fifteen consecutive rings or contours, counting from the sea to the summit of Mont Blanc, represent as many thousand feet of elevation.

The first attempt at this kind of projection was made by M. Dupin Triel on a map of France entitled "New Method of Expressing Altitudes on Maps, with a Memoir by M. Du Caila," published at Paris in 1784.[1] "If," says the latter, "we join together by one line all the points which, on a marine Chart, are marked with equal soundings, the contour of such line will be that of a section made at the bottom of the sea, on a horizontal plane, sunk below the surface of the water to an extent equal to the number of fathoms contained in the soundings." Reversing this process, by rising above the surface of the sea instead of descending below it, and proceeding on similar data, he proposed to represent, geometrically, the configuration of the surface of a country. The method consists in tracing on a map all the lines which pass through points placed on the same level, or at the same height above the mean surface of the ocean; which lines would successively become the margin of the sea, if it were by any means raised to the position where they are placed, in the same manner as the lines which join the soundings of equal depth would form its shores, if it were lowered to the number of fathoms marked in the soundings.

The spaces between these lines, or horizontal sections of the earth, are graduated according to the scale of the map and the nature of the country to be represented. Where this is flat, the contours will be placed at wide intervals; and in proportion as the country rises, they will gradually approach each other. Plateaux or table-lands are defined by the lines of level which surround them. Thus, if we conceive lines so placed as to cut these contours at right angles, we have the inclinations of greatest declivity, or those in which water descends from the tops of mountains; because lines cutting the contours at *right angles* descend directly down the mountain side, and are steeper than those making circuitous slopes around its sides. The system of contouring is now fully appreciated, and its general introduction on maps of our own country has been ably advocated by men of eminent scientific attainments.[2]

If an observer, placed on the summit of Mont Blanc, could so extend his vision as to embrace at one view the whole of Europe, he would find his position to be the culminating, and nearly the central, point of a long range of mountains, commencing at Cape St Vincent on the W., and terminating at Cape Matapan on the E. He would perceive that several branches, detached from the main chain, traverse the Iberian peninsula, and that a formidable barrier rises between France and Spain. At the portion of the system nearest himself he would see it separating France from Italy, covering Switzerland and the Tyrol with its ramifications, and extending S.E. to Albania, where it forms one of the shores of the Adriatic, the other side of which is inclosed by the remarkable chain of the Apennines. Beyond the Gulf of Genoa, and in the same direction, he would notice two great islands formed by a chain of mountains extending due S., and cut into unequal portions by the sea. Farther east he would remark, in Sicily, a continuation of the Italian chain, crossing near Nicosia, and giving to the island a triangular form. On the S. frontier of Servia the chain bifurcates, one branch taking a southern direction towards Greece, while the other bends E. and S.E. to the shores of the Black Sea. North of the latter branch he would distinguish a range of mountains which first stretches in a direction perpendicular to the course of the Danube, and is cut by that river near Orsova; it then re-curves so as to envelop Transylvania, Hungary, Moravia, and Bohemia. To the west of these, several small groups of hills are distributed over western Germany, but beyond these slight elevations he would perceive only vast undulating plains, extending to the shores of the Baltic and the North Sea. Beyond these seas, in the west, he would descry the hills of Wales and Scotland, and in the north the mountains of Scandinavia, the latter blanched by perpetual snows, due less to elevation than their proximity to the pole. If this supposed view were enjoyed during the heat of summer, when the snow is melted from the lesser heights, the brilliancy of those on which it always rests would distinguish the most elevated summits.[3]

The portion of Europe embraced in this map comprises six principal masses or systems of mountains, of which that forming the centre, much greater than all the others together, includes a large portion of the high land of France, and the mountains of Switzerland, Italy, Turkey, Hungary, and Germany. This has been termed the *Alpine system*, because the Alps form the centre whence all its branches are derived. S.W. of the Alpine system are the mountains of the Spanish peninsula, the centre of which is a vast table-land, which supports the mountains of Guadarama, the mountains of Toledo, and those of the Sierra Morena. This is called the *Iberian system*, from the ancient name of the country. The islands of Corsica and Sardinia, formerly united, comprise the *Sardo-Corsican system*. In the centre of European Russia a vast plateau, of little elevation, gives origin to the rivers Duna and Volga. The slight elevations which rise on this plateau are called the Valdai Hills, which, though only 1,100 feet above the level of the ocean, are of great importance, since they form the water-shed between the Baltic and the Black and Caspian Seas. They have, therefore, been designated as the *Sarmatian system*. Scotland, England, and Ireland form the *British system*, and the mountains of Sweden and Norway the *Scandinavian system*. These different systems are distinguished by colours on the map, and the culminating and other prominent points of each are given in the Table below.

The horizontal areas are accurately indicated on the map, by the adoption of varied depths of shading—the object being to produce, by means of hatched lines, such a relief of the ground as to give the effect of a reduced model of the country.

In order to preserve the distinctness of the orographic features of the map, the names of the great mountain chains are omitted, and those of separate mountain peaks, villages, &c., are abbreviated; but the following Abstract of the principal Mountain Systems, and the Table of Abbreviations, will, it is hoped, supply the omissions:—

TABLE OF THE CULMINATING AND OTHER POINTS OF THE SIX GREAT MOUNTAIN-SYSTEMS OF EUROPE.

Hesperian System.—This system comprises all the mountains and table-lands of the ancient Hesperia, now the kingdoms of Spain and Portugal, and all the mountains of France south of the Garonne. Its principal divisions are—I. The *Northern chain, or the Pyrenees*, extending, in the widest sense of the term, from Cape Creux on the east, to Cape Finisterre on the west; but, as more commonly understood, it is limited on the west by the meridian of Bayonne. Its highest point is Pic Nethou, or Maladetta, 11,168 feet; Canigou, long considered the highest point of the Pyrenees, is only 9,137 feet. II. The *Central or Cantabrian chain*, comprising the sierras of *Estrella*, *Gredos*, *Guadarama*, and *Molina*. Its highest point is in the Sierra Gredos, 10,552 feet. The summit of the Sierra Estrella, erroneously considered as the highest in the kingdom, is only 6,886 feet. III. The *Southern or Beticus chain*, called also the *Sierra Nevada*, the extreme south-west part of which is formed by the rock of Gibraltar. The Cerro de Mulahaçen, in Granada, 11,663 feet, is the culminating point of this chain and of the whole peninsula.

Alpine System.—This vast system, according to Bruguière, covers the whole of central, and part of southern Europe, and the Alps proper comprise the culminating points of the whole continent. The principal chain of the Alps, which is remarkably continuous, extends from Genoa in Sardinia, to Vienna in Lower Austria. It comprises the Pennine Alps, of which Mont Blanc, in Sardinia, 15,744 feet in elevation, is the culminating point of Europe, and Monte Rosa, 15,174 feet,—the Cottian Alps, with the Pic des Ecrins or Arsines, in the department of Hautes Alpes, 13,467 feet, the culminating point of France,—the Rhætian Alps, in which the Ortler Spitz, at the western extremity of the Tyrol, 12,811 feet, is the culminating point of the Austrian empire,—the Noric Alps, with the Gross-Glockner, between Salzburg, the Tyrol, and Carinthia, 12,431 feet in elevation. Its chief secondary divisions are—I. In the north, the *Bernese Alps*, which separate the cantons of Valais and Berne, the highest point of which, the Finster-Aar-Horn, 14,026 feet, is the culminating point of Switzerland. II. The *Vorarlberg chain* in the Tyrol, Swabia, and Bavaria—culminating point, the Hochspitze, 10,330 feet. III. The *Carnic and Julian Alps*, which separate northern Italy from Carinthia and part of Carniola—culminating point, La Marmolata in Austria, 9,892 feet, and Mount Terglou, also in Austria, 9,366 feet. IV. The *Jura chain*, which traverses the west of Switzerland and part of France—culminating point, Le Molesson in France, 6,584 feet. V. The *Gallo-Francian mountains*, which comprise generally all the mountains of France north of the Garonne and west of the Rhone. Its principal chains are the Cevennes, of which the Puy-de-Sancy, in the department Puy-de-Dôme, 6,220 feet in elevation, is the culminating point of the whole system. And the Vosges, in which the Ballon de Guebwiller rises to 4,690 feet. VI. The *Chain of the Apennines*, which traverses the whole of the Italian peninsula from the N.W., where it separates from the Alps in Sardinia, to the Strait of Messina, beyond which it reappears in Sicily, where it forms the insular Apennines. Its culminating points are, the Monte Corno, in the Gran Sasso d' Italia, 10,114 feet, and Mount Etna, in Sicily, 10,874 feet. VII. The *Slavo-Hellenic system or Eastern Alps*, which embraces all the mountains on the south of the Danube, in the Ottoman empire, and those of Dalmatia and Croatia, in Austria: it presents two principal chains—the western, which extends over Croatia, Dalmatia, Bosnia, Servia, Herzegovina, Montenegro, and Albania, separates the latter from Macedonia and Thessaly, traverses Greece, and terminates at Cape Matapan, in the Morea. Its culminating point is Mount Olympus, in Thessaly, 9,749 feet;—the highest point in Greece being Mount Guiona, in Doris, 8,241 feet. The eastern chain traverses Macedonia, Thrace, part of Upper Moesia and Bulgaria or Lower Moesia. Its culminating points are the Rilodagh (ancient Rhodope), 8,513 feet; the Great Balkan, highest point of the ancient Hæmus, 8,874 feet; and Athos, or Monte Santo, 9,628 feet. VIII. The *Hercinio-Carpathian system* comprises all the mountains and heights extending between the Rhine, the Dnieper, the Danube, the plains of North Germany, and those of West Poland. The principal chain assumes different names according to the country through which it passes: it is called the Carpathians or Krapacks, between Transylvania and Hungary on one side, and Moldavia and Galicia on the other. The culminating point of the Carpathians and of the whole system, is Mount Butschetje in Transylvania, 9,258 feet;—the Lomnitzer Spitze in the Tatra group, formerly reckoned the highest, being only 8,779 feet. The Sudetic mountains or Riesengebirge, between Bohemia and Silesia; culminating point, the Schneekoppe, in Silesia, 5,255 feet, which is the highest point in the Prussian monarchy. Erzgebirge, between Bohemia and Saxony, Hercynian Mountains proper, or the Rauhe Alp, the German Jura and Schwarzwald, in Würtemberg and Baden; culminating point, the Feldberg in Schwarzwald, 4,675 feet. Among the lesser chains detached from it, are the Böhmerwald; culminating point, the Gross-Arberg, in Bavaria, 4,832 feet;—the Thüringerwald; culminating point, the Gross-Beer, 3,261 feet;—and the Harz; culminating point, the Brocken, in the Upper Harz, 3,740 feet.

Sardo-Corsican System.—Mont Rotondo, in Corsica, is the culminating point of this system, being 9,068 feet in elevation. Mont Genargentu, the highest point in Sardinia, is 6,000 feet.

Sarmatian System.—This system comprises the undulating and hilly ground of Central Russia, and is only important as forming the water-shed between the Baltic and the Black and Caspian Seas: no part of it rises higher than the Valdai Hills, 1,100 feet.

British System.—Ben Nevis, in Inverness-shire, Scotland, 4368 feet, is the culminating point of the whole system. In the mountains of Cumberland, Crossfell, 3,383 feet, is the highest point; and in Wales, Snowdon is 3,557 feet. Curran Tual, in the county of Kerry, 3,410 feet, is the highest point in Ireland.

The Scandinavian System comprises the whole of the mountains of Norway and Sweden, Lapland and Finland. The mountains of Norway form broad flat table-lands, separated at intervals by deep narrow valleys, and topped by small elevations. These are called fjelds, the principal of which are the Dovre-fjeld, or Defrines, Lange-fjeld, Sogne-fjeld, Fille-fjeld, and Hardanger-fjeld. The highest point of the peninsula is about 8,500 feet. Sneehätten, in latitude 62°, is 7,520 feet.

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[1] The idea originated with Ph. Buache, when observing the successive intersections made by a receding or rising tide, on the plane of the surface of the sea, on a varied coast. He and others proposed the adoption of normal contours for marking lines of equal soundings on marine charts.—*See Mémoires de l'Academie des Sciences*—1752, p. 399; 1753, p. 586; and 1756, p. 109.

[2] Further information on this beautiful and simple method of delineation will be found in the following treatises:—Instructions données en 1808 aux Ingénieurs Géographes, par l'Administration du Dépôt de la Guerre. Paris. Traité de Topographie d'Arpentage et de Nivellement. Par L. Puissant. P. 2:6. Paris: 1820.—Précis de la Geographie Universelle. Par Malte Brun et Huot. Tome ii., p. 165. Paris: 1832.—Report of Proceedings of British Association for the Advancement of Science, held at Cork: 1843.—Highland Society's Journal of Agriculture. Edinburgh: 1844.—Journal of the Royal Geographical Society of London, vol. xiv., p. 58.—Practical Geodesy. By Butler Williams. London: 1842.—And Edinburgh New Philosophical Journal, January, 1845.

[3] See Orographie de l'Europe. Par M. Louis Bruguière. Paris: 1830.

ALPHABETICAL LIST OF ABBREVIATIONS, WITH THEIR EXPLANATIONS.

A

An.	Annecy (West Alps).
As.	Asiago (South Alps).
Aal.	Aalen (Swabian Jura).
Alb.	Albano (near Rome).
Alessan.	Alessandria.
Alp.	Alpines (South France).
App.	Appenzell.
Aq.	Aquila (Abruzzo).
Are.	Arezzo (Tuscany).
Arg.	Argenik (Albania).
Arnsb.	Arnsberg.
Aschf.	Aschaffenburg.

B

B.	Bellinzona.
B.	Boja (Albania).
B.	Borgo (near Trient).
B.	Buchau (Bohemia).
Baba.	Babagura or Babia-Gura (Carpathians).
Bad.	Baden.
Ball. A.	Ballon d'Alsace (Vosges).
Ball. S.	Ballon of Sulz "
Banial.	Banialuka (Bosnia).
Barcel.	Barcelonette (West Alps).
Bass.	Bassano (Upper Italy).
B. C.	Ben Cruachan.
Beachy Hd.	Beachy Head.
Bell.	Belluno (South Alps).
Ber.	Pass Bernina (Central Alps).
Besan.	Besançon.
Bibr.	Biberach.
B. L.	Ben Lomond.
Bl.	Blauberg.
B. Lawers	Ben Lawers.
Bles.	Blessberg (Thüringer Wald).
B. More	Ben More.
B. M. D.	Ben-na-muic-dhui.
B. Nevis	Ben Nevis.
Bo.	Botzen (Tyrol).
Bod.	Bodenburg.
Bog.	Bogaskoe (Turkey).
Bothlegh	Bothley Hill.
Bourg.	Bourges.
Br.	Bruley (Lorraine.)
Bren.	Brenner Pass.
Bress.	Bressuire.
Bria.	Briançon.
Brock.	Brocken.
Budw.	Budweis.
Bug.	Bugiaki (Greece).
Bull B.	Bull-Barrow.
Butt.	Buttenhausen.
Bx.	Brüx (Bohemia).
Bz.	Bautzen.

C

C.	Cascia, Civita di (Abruzzo).
C.	Cassel (Hessen).
C.	Castonia (Macedonia).
C.	Corno di Canzo (South Alps).
C.	Croja (Albania).
Ca.	Castellvecio [1] (Abruzzo).
Cab. d. Maria	Cabeza de Maria.
Cahircr.	Cahirconree, or Cahirconrigh.
Calm.	Calmuck.
Can.	Canigou (Pyrenees).
Cantal.	Plomb du Cantal.
Car.	Cares.
Carc.	Carcasonne.
Carlsrh.	Carlsruhe.
Cartf.	Carterfell.
Cas.	Casale.
Cast.	Castelnaudary.
C. D.	Civita Ducale (Abruzzo).
C. d'A.	Cima d'Asta (South Alps).
C. d. F.	Col de Fenêtres.
C. d. L.	Canal de Languedoc.
C. d. P.	Cima di Portola.
Cerd.	Cerdon.
C. G.	Cairngorm.
Ch.	Chasseron (Helvetian Jura).
Ch.	Choczer Peak (Carpathians).
Ch.	Chur (Grisons).
Chart.	Chartreuse, Great.
Ch. bl.	Montagnes du Cheval Blanc.
Chi.	Chiavenna (South Alps).
Cist.	Cisterna.
Cler.	Clermont.
C. M.	Cerro Mulhaçen.
C. Mat.	Cape Matapan.
Cob.	Coburg.
Cobl.	Coblenz.
Col.	Colmar.
Col-B.	Col-Berg.
Const.	Constantinople.
C. R.	Col. Roburent.
Crif.	Criffel.
Cucuz.	Cucuzzo, Monte.

D

D.	Diumbier (Carpathians).
D.	Dolmar (Thüringer Wald).
Darm.	Darmstadt.
D. Brod.	Deutsch Brod (Bohemia).
D. d. M.	Dent du Midi.
Di.	Diablerets (Central Alps).
Dj.	Dijon (France).
Dj.	Djumerka (Albania).
D. O.	Domodossola.
Do	Dödi.
Dörn.	Dörnberg.
Dov.	Dovrefield.
Dres.	Dresden.
Dreys.	Dreysesselberg.
Düssel.	Düsseldorf.

E

E.	Etropol.
Eg.	Eggenburg.
Egri Pal.	Egri Palanka.
Eichf.	Eichsfeld.
Eis.	Eisenhut.
El. M.	Elatea Mountain (Greece).
Epi.	Epinal.
Erbs.	Erbsenkopf Wald.
Escudo.	Escudo, Alta del (Cantabr. Mountains).
Eski S.	Eski Sagra.
Espad.	Cerro de Espadan.
Eto.	Grande Etoile.
Etter.	Ettersberg (near Weimar).

F

F.	Feltre (Venice).
F.	Florina (Macedonia).
F.	Frankenheim (on the Rhone).
F.	Friedberg (Bohemia).
F. A.	Finster-Aarhorn.
Fa.	Fatra.
Fa.	Fatra (Hungary).
Fag.	Les Fagnes.
Falk.	Falknis-Berg.
F. d'Othe	Foret d'Othe.
Fe.	Felizzano (Piedmont).
Feldb.	Feldberg (Schwarzwald).
Feldb.	Feldberg (Taunus).
Fich.	Fichtelberg (Erzgeb).
Fins.	Finstermünz.
Fion.	Fioncho, Monte.
Fo.	Foligno.
Folgef.	Folgefond.
For.	Formentera.
Fr.	Freiburg.
Frbg.	Freyberg.
Freiw.	Freiwalde.
Frey.	Freystadt.
Fu.	Fulda.
Füss.	Füssen.

G

G.	Gazza, Monte (South Alps).
G.	Gotha.
Ga.	Gallenstock.
Gal.	Galgenberg.
Gar.	Guarda.
G. B.	Gleichberg, Great.
Gb.	Goldappberg.
Geb.	Gebirge.
Geiersb.	Geiersberg.
G. d'A.	Glacier d'Ambin (West Alps).
Gib.-Ros.	Monte Gibel-Rosso.
Gies.	Giessen.
Glockner.	Glockner, Gross.
Gmd.	Gemund.
Golmb.	Golmberg.
Görlz.	Görlitz.
Gött.	Göttingen.
G. Pelv.	Pelvoux, Great.
Gr.	Gries, or Grieshorn Pass (Central Alps).
Gr.	Gronau (Westphalia).
Grossh.	Grossenhain.
Gsb.	Geisberg, or Gaisberg.
G. St B.	Great St Bernard.
Guadarrama	Puerto de Guadaramma.
Gut.	Gutenbrunnen.

H

H.	Halle (on the Saale).
H.	Hamm (Westphalia).
H.	Hochgailing (East Alps).
H.	Hohenstein (Prussia).
Hagb.	Hagelsberg.
Hallås.	Hallandsås.
Halling.	Hallingskarven.
Hareb.	Harebarken.
Hasen.	Hasenmatte.
Hb.	Haasenberg (Prussia).
Hb.	Hardenberg (Netherlands)
Heil.	Heilsberg.
Herje.	Herjehågen.
Herrmanst.	Herrmanstadt.
H. G.	Hohe Göll.
Hlstein.	Hohenstein.
Hk.	Hochkant.
Hlzm.	Holzminden.
Hö.	Hörnli.
Ho. G.	Hohgant.
Hohb.	Hohenberg.
Hoh. E.	Hohen-Elbe.
Honru.	Honrubia.
Hoyersw.	Hoyerswerda.
Hrad. B.	Hradawa Mountains.
Hum.	Hummelfield.
H. Vog.	Hochvogel.

I

Ilz.	Ilanz.
In.	Inselsberg.
Ingol.	Ingolstadt.
Inkp.	Inkpen Beacon.
Insb.	Innsbruck.
Ioracov.	Ioracovuni.
Isch.	Ischel.
Iser. K.	Iserkamm.
Ist.	Istib.
Iv.	Iviza.

J

J.	Janina (Albania).
J.	Jungfrau (Central Alps).
Jabl.	Jablunka Pass.
Jav.	Javorie.
Jaxt.	Jaxtfeld.
Jeni S.	Jeni Sagra.
Jes. B.	Jeschkenberg.
Jor.	Jorat.
Judb.	Judenburg.
Justed.	Justedal.

K

K.	Kalkandel (Albania).
K.	Kesohan (Thrace).
K.	Kralowa-Hola (Carpathians).
K. Ast.	Kahle Astenberg (Lower Rhine).
Katsch.	Katschanik.
Katzeb.	Katzenbuckel.
Kb.	Karlsbad (Bohemia).
K'be.	Kohautberg (Böhmer Wald.)
Kbg.	Kongsberg.
Kemp.	Kempten.
Kez.	Kezanlik.
Kgsving.	Kongsvinger (Glommen Mountains).
Khel.	Khelmos.
Kl.	Kleck.
Klagenf.	Klagenfurth.
Klatt.	Klattau.
Knock M. D.	Knock-Meal-Down.
Koj.	Kojani.
Könb.	Königsbrunn.
Königg.	Königgrätz.
Kornbg.	Kornberg, Great.
Kpla.	Kapella, Mount.
Kr.	Krems (Austria).
Kr.	Kritschowo.
Kr.	Kriwan (Tatra Group).
Kr. B.	Kreüsberg.

L

L.	Langres (France).
L.	Larissa (Thessaly).
L.	Leontfelden (Böhmer Wald.)
L.	Liebkowitz (Bohemia).
L.	Lionessa (Abruzzo).
Lend.	Landau.
Landk.	Landeskrone.
Lanf.	Lanfains.
Layb.	Laybach.
L. Ch.	La Charité.
L. d. Cela.	Lago di Celano, or Fucino.
L. d. G.	Lago di Garda.
Lébé.	Lébéron, Chaine de.
Lei.	Böhmisch Leipa.
Leip.	Leipzig.
Leit.	Leitmeritz.
Leob.	Leoben.
Leobsch.	Leobschütz.
L. F.	La Foya, culminating point of the Sierra Monchique.
Licht.	Lichtenberg.
Lign.	Lignières.
Lilien.	Lilienfeldt.
L. L.	Loch Lochy.
L. M.	Lago Maggiore.
L. M.	Lammermoor Hills.
L. N.	Loch Ness.
Lodals.	Lodals Raabe.
Loibl.	Loibel.
Lom.	Lomnitz Peak (Tatra Groupe).
Luxbg.	Luxemburg.
Lwh.	Lowther Hills.

M

M.	Macon (France).
M.	Magdeburg.
M.	Malgara (Thracia).
M.	Marauser See (Prussia).
M.	Col de Manchéron (Jura).
M.	Mainz.
M.	Melenik (Macedonia).
M.	Mesuil la Horgne (Lotharingia).
M.	Metzovo (Albania).
M.	Mulhaçen, Cerro de (S. Nevada).
M.	Münster (Vallais).
Magil. R.	Magillicuddy's Reeks (summit Carn Tual).
Mal.	Maladetta [2] (Pyrenees).
Man.	Mannheim.
Mar.	Marlow (Mecklenburg).
Mar.	Marmelata (South Alps).
Mar.	Marseilles.
Märeskal.	Märeskalsfjeld.
Margar.	Margaride.
Matagall.	Matagallos.
Mb.	Marienburg.
M. B.	Mont Bousser (South Alps).
M. B.	Monte Brunone (South Alps).
Mbg.	Marienberg (Saxony).
Mbg.	Müggelsberg (near Berlin).
M. C.	Insel Monte Christo (near Corsica).
M. C.	Mont Carnera (Central Alps).
M. C.	Monte Cavo (near Rome).
M. C.	Mont Cenis (West Alps).
M. C.	Mont Colombier (Helvetian Jura).
M. Capan.	Mont Capanne.
M. Ci.	Monte Cimone.
M. D.	Mont Dauphin.
M. d. Ares.	Muela de Ares.
M. d. Charol.	Montagnes du Charolais.
M. d. Ester.	Montagnes d'Estrella.
M. d. L.	Montagnes de Lure (South Alps).
M. d. l. C.	Montagnes de la Caune.
M. d. M.	Montagnes des Maures.
M. d. Margh.	Montagnes de Marghine.
M. d. Mor.	Montagnes de Morvan.
M. d. Taor.	Mola di Taormina.
Med.	Mediasch.
Medven.	Medvenik.
Meis.	Meissner.
Memm.	Memmingen.
Mendip.	Mendip Hills.
M. Fich.	Mont Ficherino.
M. four.	Mealfourvouny.
M. G.	Monte Ganio, or Gavio (near the Ortler).
M. G.	Monte Genoeso (on Lago-di Garda).
M. Goth.	Mont St Gothard.
M. Grr.	Mont Grenier.
Min.	Minden.
Miös.	Miösen Lake.
Miltenb.	Miltenberg.
Mit.	Mitrowitza.
Mittg.	Mittelgebirge.
M. Jav.	Mont Javoult.
M. Jar.	Mont Jargean.
Ml.	Meleda Island.
M. Leg.	Monte Legnone (South Alps).
M. L.	Mont Louis (Pyrenees).
Mlbk.	Melibokus.
M. M.	Mount Malevo.
M. M.	Munna Magi.
M. Mag.	Monte Maggiore.
M. Mau.	Mauro, Monte St.
Mol.	Molesson.
Mon.	Montabaner.
Montp.	Montpellier.
Mos.	Montagnes de Mosset, or Mousset.
Mos.	Mostar (Herzegowina).
Mouch.	Mouchérol.
Mout.	Mouthe.
Mp.	Meppen.
M. Pi.	Monte Pistoia.
M. Sc.	Monte Scopo.
M. Sorian.	Monte Soriano.
M. St Ang.	Monte San Angelo.
M. T.	Monte Terrible.
M. Tor.	Mont Toro (Minorca).
Munich.	München.
Mugn.	Mugnarfield.
M. V.	Monte Venda.
M. Ven.	Monte Ventoux.

N

N.	Nevesign (Herzegowina).
N.	Narcia (Abruzzo).
Neid.	Neidenburg.
Ner. Pl.	Neretzka Planina Mountain.
Nh.	Neüenhaus.
Nord.	Nordhausen.
Nörd.	Nördlingen.
Nov.	Novibazar.
Nürnb.	Nürnberg.

O

O.	Oro, Monte dell'.
Ob.	Oberndorff (Schwarzwald).
Obi.	Obiou, or Obioux (South Alps).
Ochkpf.	Ochsenkopf.
Odenw.	Odenwald.
O. Fa.	Ozthaler (Farther).
Olb.	Olberg.
Om P.	Om Planina.
Or.	Oranienburg.
Os.	Ossero, Monte.
Osman B.	Osman Bazar.
Osnb.	Osnabruck.
Ozmi.	Ozmiana, Heights of.

P

P.	Padua.
P.	Petersberg (near Halle).
P.	Prespa (Maced., East of Lake Ochri).
P.	Prilip (Macedonia).
P.	Prisvan (Albania).
Pad.	Paderborn (Westphalia).
Pad.	Padolia.
Pap.	Paproder Berg.
P. B.	Peissenberg.
P. H.	Pentland Hills.
Pdam.	Potsdam.
P. d. Catania	Piana di Catania.
P. d. E.	Perron des Encombres.
P. d. F.	Pic de Fortangent.
P. d. Guadarra	Puerto de Guadarama.
P. d.	Puerto de Monasterio.
P. d. M.	Puy de Montocelle.
P. d. Plat.	Puerto de la Plata.
P. d. Rey.	Puerto del Rey.
Pell.	M. Pellegrino (Sicily).
Penm.	Penmaen-Mawr.
Penngl.	Pennagolosa.
Per.	Perindagh.
Peterw.	Peterwardein.
Phil.	Philippopel.
Piano d. C. M.	Piano di Cinque Miglia.
Pirm.	Pirmasenz.
Plasch. Geb.	Plaschkavitza Mountain.
Plo.	Plochingen.
Plock.	Plockenstein.
Pd. M. d. B.	Pic du Midi de Bigorre.
Pd. M. d. P.	Pic du Midi de Pau.
Pod.	Podgoritza.
Poj	Pojani.
Po.	Pokroi.
Polig.	Polingny.
Por.	Porim.
Potz.	Potzberg.
P. P.	Pic Posets.
P. s. Calm	Puy se Calm.
P. s. Haute	Pierre sur Haute.
P. V.	Pic Vieil.
P. W.	Porta Westphalica.

Q

Qued.	Quedlinburg.
Queth.	Quantock Hills.

R

R.	Radstädter Tauern (East Alps).
R.	Rasluk (on Despoto Dagh).
R.	Ravensberg (near Potsdam).
R.	Reculet (Jura).
R.	Rieta (Middle Apennines).
R.	Ronda.
Radico.	Radicofani.
Ramp.	Rampillon.
Rath	Rathhausberg.
Rb.	Riesenberg.
Rb.	Rossberg.
Rein.	Reinerz.
Res.	Reschen-Scheideck.
Regensbg.	Regensburg (Ratisbon).
Roc. Corva.	Rocca Corva.
Roch.	Rocca Melone, or Roche Melon.
Romsd.	Romsdal.
Ronc.	Ronces Valles, or Roncevaux.
Rück.	Rückenberg.
Rund.	Rundene (Rundafjeld Pickhätten).
Rut.	Rutefjeld.

S

S.	Saaz (Bohemia).
S.	Seres (Macedonia).
S.	Splügen (Central Alps).
Saarbg.	Saarburg.
S. Alham.	Sierra de Alhama.
S. Arabid.	Sierra d'Arrabida (culminating point of the Formosinho).
Sal.	Salfjeld.
Sal.	Salona.
Salinas	Salinas (Sierra de).
Sall.	Sallanche.
Sap.	Sapada, or Sapeda.
Salzb.	Salzberg.
Sb.	Schönningerberg.
Sc.	Scutari.
Sch.	Schalia (Albania).
Schemn. M.	Schemnitz Mountain.
Sch.	Monte Schiena d'Asino (near Rome).
Sch.	Schio, City (near Verona).
Sch.	Schneekopf (Thüringer Wald).
Sch.	Schwerin (Meklenburg).
Schaf.	Schafhausen.
Schaum.	Schaumburg.
Schb.	Schneeberg, Town.
Schl.	Schlern, Berg.
Schn.	Schneeberg (East Alps).
Schn.	Schneeberg (Sudetic Mountains).
Schneek.	Schneekoppe.
S. D.	St Dié, or St Diey.
Shehall.	Shehallion, or Shehallien.
Serr.	Serre.
Sey.	Seyssel.
Sez.	Sezza.
Siebengb.	Siebengebirge (seven Mountains).
Sieg.	Siegen.
Sigm.	Sigmaringen.
Sim.	Simplon.
Skagstöl.	Skagastölstind.
Skr.	Skarven.
Skurdl.	Skurdalsporten (road near Lake Skurdal).
Sm.	Semmelberg.
S. M.	St Marie aux Mines.
Sneeb.	Schneeberg (near Triest).
Sneeb.	Schneeberg (near Vienna).
Solst.	Sollstein.
Somp.	Sompuis.
Sp.	Spoleto.
S. R.	See Rikavetz (Lake Rikavitz).
S. Alba.	Sierras Albas (Cantab. Mountains).
Sr. d. Guara	Sierra de Guara.
S. Sal.	San Salvador.
St.	Hohe Sentis.
St.	Sterzing (Tyrol).
St.	Strela, or Türkli Scheideck (Grisons).
St. Alp.	Stang-Alp.
St. B.	St Bernard (Little).
St. Ben.	St Benedik.
Sternb.	Sternberg.
St G.	St Genis, or St Genix.
St Hy.	St Hyppolit.
St Ifo.	St Ildefonso.
St Im.	St Imier.
St J.	St Johann.
S. Tja.	Sierra Tejada.
St Jean P. d. P.	St Jean Pied de Port.
St Marcel.	St Marcello.
St M. d. Ch.	St Martin de Chantion.
St Max.	St Maximin.
St Mh.	St Ménéhould.
Stor. S.	Storsiöen.
Str.	Stralsund.
St L.	St Lovelin.
St Ste.	St Stefano.
St Stef.	St Stefano.
Stutt.	Stuttggard.
St V.	St Victoire Mountain.
Such.	Suchet Mountain.
Sul.	Sulmona.
Sychar.	Sycharitza.
Sylt.	Syltfjeld, or Syltkop.
Sz.	Szawl.

T

T.	Tagliaferro (Central Alps).
T.	Teschen (Bohemia).
T.	Toussaines (Bretagne).
T.	Tricala (Thessaly).
T.	Trajak (Macedonia).
Tach.	Tachau.
Tag.	Tagliacosso.
Tam.	Tamsweg.
Tarasc.	Tarascon.
T. Draj.	Teleuka Draja.
Tei.	Teinitz.
Temp.	Templin.
Ten.	Hohe Tennergebirge.
Tend.	Mont Tendre.
Termi.	Terminillo, Grande and Piccolo.
Teütob. W.	Teütoburger Wald.
Th.	Thurndorf.
Ti.	Tivoli.
Tob.	Toblach.
Tomor.	Tomoros.
Torg.	Torgau.
Torinna.	Sierra de Torinnona.
Tr.	Mont Trelot (West Alps).
Tr.	Trient.
Tr.	Trier.
Tripl.	Tripolitza.
Tronf.	Tronfjeld.
Tsch.	Tshainitza.
Tstein.	Traunstein.

U

Ullensv.	Ullensvang.
Usk.	Uskiub.

V

V.	Veleta, Pic (Sierra Nevada)
V.	Grand Ventron (Vosges).
V.	Vicenza (Upper Italy).
V.	Vigo (Tyrol).
V.	Vogel (Source of Rhine).
Vald.	Miösenwand (in the Vale of Valders).
Valp.	Valplan.
Vattc.	Vattendalsfjeld, Pass of.
V. d. D.	Val de Dieu.
Vel.	Velutschi (Greece).
Venas.	Venasque.
Verd.	Verdun.
V.-franca	Villa-Franca.
Vig.	Vignemale (Pyrenees).
Vigl.	Vigelnsfjeld (Vigelns Peak).
Vill.	Villach (East Alps).
Vill.	Villingen (Schwarzwald).
Voi.	Voirans.
Vran.	Vranatz.

W

W.	Wildberg.
Wazm.	Wazmann.
Weim.	Weimar.
Westerw.	Westerwald.
Wildh.	Wildenhof.
Witt.	Wittenberg.
W. R.	Wormser Ridge.
Wz.	Wesel.
Wsl.	Wessely.
Würzbg.	Würzburg.

Y

Yve.	Yverdon.

Z

Z.	Zürich.
Zirkn S.	Zirknitzer See.
Z. M.	Zeda Monte.
Zw.	Zwettel.

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[1] The highest valley in the Apennines, 4762 feet high.—*Schouw.*

[2] On Maladetta (Mont Maudit) is Pic Nethou or Anethou, the culminating point of the Pyrenees.

PLATE 4

GEOLOGICAL MAP OF EUROPE,

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IN this Map we have endeavoured to represent, in a very general manner, the geological features of Europe and the shores of the Mediterranean, so far as they have been ascertained by recent investigations. In conformity with the design of our work, we have selected the formations laid down partly from geographical, partly from geological considerations. Thus, some formations cover a larger space, and exercise a greater influence on the physical features of the earth than others, and have on this account higher claims to be distinguished in any general work on geographical geology. Of this kind are the older igneous and metamorphic rocks, in some localities extending over very wide tracts of country; in other places, where they have a smaller appearance on the map, forming the hard parts, or skeleton, round which the newer formations have been deposited. The same reason applies to the older palæozoic strata (Silurian), often composing, with the former groups, the central masses of the most important mountain-chains, and like them spreading over large tracts of country. In addition to these mere geographical reasons, they also possess a high geological interest, as the first beds in which traces of organic life appear. The newer palæozoic strata, containing, as the central group, the carboniferous limestone and coal, have also much interest, from the number of their organic remains and the economic value of their minerals. The secondary, or mesozoic strata, though spread over considerable spaces, have, except in the Alps and a few other mountain-chains, had in general a less marked influence on the regions they form, but deserve special notice from the number of remarkable fossils they contain. The tertiary strata, again, require to be distinguished, from the wide spaces they occupy, the rich profusion and variety of organic life which they display, and even from constituting an important part in the physical structure of the Alps and other chief mountain groups.

These are a few of the general considerations by which we have been determined in the choice of the formations represented. The scale of the Map also rendered it desirable to avoid entering into greater details. These will be found in another map, which we are now engaged in preparing on four sheets, each of them of the same dimensions as the present map, which may be considered as a key to the larger work.* A short account of each group, and of the subordinate rocks they contain, is given in the following notices. The authorities consulted for different portions of the map have been so numerous that any complete enumeration of them is impossible. A few of the more important may, however, be here mentioned, especially those whose labours extend over wide tracts of country.

Beginning with the north of Europe, the basis of this portion of our work has been the general map executed by one of us and his associates on the Geology of Russia and the Oural Mountains, which comprises not only that extensive empire, but also the greater part of Sweden, and large portions of Austria, Turkey, and the adjacent countries. Further particulars regarding Sweden have been taken from Hisinger's Maps, and for Norway from those of Keilhau ("Gea Norwegica," 2 vols.), combined with personal observations on several parts of both countries. For Denmark, the maps and writings of Dr Forchhammer ("Denmarks geognostishe Forhold," &c.) are the best authorities. In the British Islands we need only allude to the large maps of Greenough (England), Macculloch (Scotland), and Griffith (Ireland), with our own smaller maps of these countries (Murchison's Geological Map of England, Nicol's Geology of Scotland), Phillips' British Isles, and the Palæontological Map of the British Islands by the late Prof. Edward Forbes, which will be found in another part of the "Physical Atlas."

Germany and Central Europe are represented in a connected form in the large map of F. Hoffmann, and on a smaller scale in Von Dechen's useful map. More special maps are—Naumann and Cotta's maps of Saxony; Credner and Richter's maps of the Thüringerwald; as well as in the new map of Hessia and the surrounding tracts by Schwarzenberg and Reusse; the map of the Rhenish Provinces, by Sedgwick and Murchison; of Upper Silesia, by Von Carnal; of Bohemia, by Barrande; of Austria generally by Haidinger and his associates in the School of Mines; and the large map of the Tyrol also, by the corps of Mining Engineers. For Belgium we have consulted the elaborate maps of Dumont; whilst for France the chief authority is of course the beautiful map of Dufrénoy and E. de Beaumont. The geological structure of the Iberian peninsula has hitherto been very imperfectly known; but besides the published maps of the whole country by Ezquerro del Bayo and Wilkomm, and of particular portions by Schultz, Le Play, D. Sharpe and others, our associate De Verneuil has furnished us with a coloured map embodying many of his most recent researches. Corsica, Sardinia, and the Balearic Islands are entirely taken from a sketch of these islands kindly prepared for our use by General della Marmora, chiefly from his personal surveys.

Notwithstanding the labours of so many distinguished naturalists, Italy and the Alps still remain a problem to geologists. The smallness of the scale, even of our large map, does not admit of more than an approximate representation of the highly complex structure of the latter remarkable mountain group. Besides the portions of the chain contained in the maps of France and Germany already mentioned, we have consulted the map of Switzerland by Studer, and that of Italy by Collegno, correcting the latter especially in many points by our own personal researches. The map of Elba by Krantz, and those of Sicily by Daubeny and Hoffmann, have also been consulted. The latter, though very elaborate, is, like Collegno's "Italy," still imperfect, M. Hoffmann having, in conformity with the prevalent opinion at the time it was prepared, united the nummulite rocks with the chalk. This defect we have only been able partially to remedy from his elaborate Memoir and personal survey.

The geology of Turkey in Europe has been delineated and described by Dr Ami Boué, but various additions have been subsequently made by Visquenel and others. Of Greece there is a map by Fiedler, and valuable materials in the "French Expedition to the Morea" by Boblaye. The islands in the Archipelago are noticed partly by Boué, partly by other authors, though many of them have been only imperfectly examined. For Asia Minor our sources of information are still more imperfect, no general map of that country having as yet been attempted. Our sketch is compiled chiefly from the information furnished by Pierre de Tchihatcheff, supplemented by the works of J. W. Hamilton, Hugh E. Strickland, the late lamented Edward Forbes, and others. Further east, Koch's Map of the Caucasian Mountains, the observations of Abich, and Grewinck's Map of the Southern Shores of the Caspian, have also been made use of. For Palestine and Syria the most detailed maps are those in Russegger's Travels. Of the African coast we have a detailed map of Algeria by M. Renou, and incidental notices in other authors.

Notwithstanding the amount of research and labour expended in investigating the geological structure of Europe, many points in its history still remain obscure. The co-ordination of some of the formations in the several countries is especially unsettled, and often occasions considerable difficulty in combining the materials furnished by different authors. The principles on which the maps of the various countries have been prepared in many cases do not correspond, and very great diversity prevails, especially in laying down the recent accumulations covering the older rocks. Whilst some observers lay down these in every place where they occur to any considerable extent, others, more in conformity to the usage in Britain, only do this where they are so abundant as to conceal the inferior formations, and determine the general character of the region. Though our personal investigations have extended over four-fifths of Europe (Russia in Europe being the larger half of the area), they have only enabled us partially to remedy these difficulties, and the Map must therefore be regarded as a first approximation only.

* The four sheets of this enlarged Map will be uniform in style with the other plates of the Atlas, and so arranged as to bind up with the volume.

CRYSTALLINE SCHISTS.

The first group distinguished in our map consists of the crystalline strata or schists of all ages. In this are included not only the normal varieties of gneiss, mica slate, talc slate, chlorite slate, clay slate, granular limestone or marble, but all the modifications of these strata, and also many other rarer crystalline compounds. On looking at the map, the chief development of these rocks is seen to be in the north, where, ranging from the west coast of the British Islands through Scandinavia, they form the high mountain-land that borders the Atlantic Ocean. In all this range—in Scotland and Scandinavia—the dominant mass is gneiss, of normal constitution, and approximating in its deeper portions to granite, and overlaid by mica slate, quartz rock, and clay slate. In Scandinavia these rocks are very rich in metallic ores and other minerals, especially near the intrusive igneous masses—as silver at Kongsberg; cobalt at Modum; copper at Fahlun, Tunaberg, Roraas, and Alten; iron, chiefly the magnetite, at Arendal, Utoe, Dannemora, and Sala—and in these mines, and also in Finland, are contained very many rare and beautiful minerals.

These rocks are in great part—certainly those of Scandinavia—of anterior date to the most ancient known fossiliferous deposits; the Lower Silurian beds—the lowest in which traces of life are known in that region, in Germany, and in Great Britain—resting unconformably upon them. We have, however, conjectured that in part the Scottish crystalline slates may represent metamorphosed Silurian strata. We have also assigned this origin to the narrow band of crystalline schists which, in the low ridges of the Oural, bound the great plain of Northern Europe on the east, and are everywhere broken through by igneous rocks. The great masses of crystalline strata on the south border of this plain are also evidently of very various age. In the Thüringerwald, they are greenish talcose, quartzose schists, which, in their extension to the northern part of the chain, have been converted into mica slate and gneiss. Near Freiberg, even the latter, as we have elsewhere stated, is apparently very different in age from the same rock in Scotland and Scandinavia.[1] The Erzgebirge with its rich mineral veins, the Fichtelgebirge, the Böhmerwald, and other mountain groups, forming the basin in which the Silurian rocks of central Bohemia were deposited, must evidently be of more ancient date. In these mountains the succession of rocks is nearly the same as in Scotland and Scandinavia, gneiss sometimes, as in the Böhmerwald, containing graphite, and only slightly inclined; and mica slate, the mica, often replaced by hornblende, chlorite, or talc, being the more common members. They have been repeatedly disturbed by subterranean action, being broken through not only by granite and quartzose porphyries, but by basalts, phonolites, pitchstones, and trachytes, as in the vicinity of Bilin and Teplitz, and also by numerous intersecting systems of mineral veins—the tin veins, as at Ehrenfriedersdorf, Marienberg, Zinnwald, being here as in other places probably the older. The smaller portion of crystalline strata in the Carpathians and eastern Austria may be regarded as the continuation of this range, and, from their connection with the older palæozoic strata in some parts, as of similar age.

The crystalline rocks of Brittany, central France, and the enormous chain of the Alps, form, as it were, a backbone, dividing Northern from Southern Europe. Though we have shown some portions of these strata in central France to be only altered carboniferous deposits,[2] yet other portions have formed the basins in which coal-beds were accumulated, and furnished the materials composing the coarse conglomerates on which they rest. In the Alps, this group embraces a far wider range of strata than perhaps in any other part of Europe. We comprise in it not only the great ellipsoidal masses, often with a fan-shaped stratification, and of doubtful relation to the associated granites, which have thrown off the newer formations around, but also the metamorphic or altered portions of these deposits, whatever may be their age. Thus the gneiss and calcareous mica slates of St Gothard, full of beautiful minerals; the slaty protogines of Mont Blanc; the talcose and chloritic slates in many parts of Switzerland and Savoy, even though their passage into the mesozoic strata of jurassic or cretaceous age can be demonstrated, must be retained in this group, not less than the older altered rocks which we have enumerated in other countries, and which are probably more common in the eastern parts of the chain. This formation, therefore, includes the greater part of the rocks described by Studer as the "palæozoic formations of the inner Alps," and by the authors of the Map of France as "altered jurassic strata." In relation to these masses, the age of the original deposits seems of less importance than the fact that they have all undergone a powerful modifying action, sufficient to obliterate most traces of their former condition.

The crystalline strata in Southern Europe have not been well distinguished from the older igneous rocks and granite. In Spain this has been only partially done in Galicia by Schultz, in Portugal by D. Sharpe, and in a few other localities by different observers; but in general the boundary lines are far from being accurately defined. In Italy, through the labours of La Marmora, Meneghini, and Savi, we have also only been able partially to separate these rocks; and in Greece and Turkey the difficulty of effecting a division is still greater, many parts of these countries being still wholly unexplored. In Asia Minor, for the same reason, the boundaries of this, as of the other formations, are even more hypothetical in many places, M. P. Tchihatcheff conjoining many of the mica slates of that region with the fossiliferous Devonian rocks.

OLDER PALÆOZOIC GROUP, OR SILURIAN SYSTEM.

First fully described and characterised by its peculiar fossils in the western parts of our own country, and then traced into Russia and Scandinavia,[3] this vast system of formations is now ascertained to occupy wide tracts, not only in Europe but in the other continents, and notably in America. Our map shows that in Europe it is chiefly exposed in the north and west, though the small portions rising to the surface in other places, through the newer strata, prove that it probably forms the foundation on which these beds have been deposited—the first stage in the long series of organic creations made known to us by geological research. In the typical regions of Wales and the adjoining counties of England, the following divisions and subdivisions have been distinguished by their peculiar organic remains, though the whole group is still intimately linked together, not only by the general character, but by many common species of fossils.

The lower Silurian consists of—1st, The Longmynd or bottom rocks, composed of slates, greywackes, or coarse conglomerates, in which, in England, no traces of life have yet been observed, and which, in some localities, especially in Anglesea, have been converted into talcose slates and quartz rocks. 2d, The Lingula slates (primordial zone of Barrande), in which that genus of molluscs and a few trilobites (Olenus and Agnostus) have been found. 3d, Llandeilo formation, of enormous masses of slates and flags, often calcareous, or with intercalated limestone beds, and also with thick igneous masses, contemporaneous or intrusive. In this portion of the series, organic life, from graptolites upwards, becomes far more abundant and diverse in its characters than in the inferior strata. 4th, The Caradoc, forming a kind of intermediate group, the lower portion connected by its fossils with the inferior Llandeilo, whilst in the higher beds a mixture of organic remains from the upper Silurian strata is found to occur; and the strata also are often conformably deposited. The upper Silurian consists of strata in which calcareous matter is more abundant, both in the composition of the arenaceous or clayey beds, and in numerous thick limestone courses. It is divided into the two formations of Wenlock and Ludlow, named from the localities where they are best exposed.

In Scotland and Ireland probably only the lower portion of the system is fully developed, including beds representing the Longmynd base, which, near Dublin, contains the peculiar zoophyte, Oldhamia; then the lowest zone in which characteristic organic remains occur, and the Caradoc, which forms a passage to the higher division or upper Silurian, which in these countries is scarcely known. In Scandinavia the series is more complete, and the rocks in ascending order are fucoid sandstone, alum schist (Lingula beds), orthoceratite limestone (Llandeilo), graptolite schists, Wenlock limestone, with a feeble representative of the uppermost Silurian or Ludlow rock. Near Christiania, the lower and upper Silurian, with their characteristic organic remains, and in united parallel masses, form repeated undulations, the rocks being chiefly black or grey clay slates, alum slates, and grey compact limestones. In Sweden, the lower division is known near the Wener and Wetter lakes, and in Œland and in Bornholm. The lowest band consists of fucoid sandstone, the next of alum slates, with Ogygia, Battus, Olenus; and the great mass of the well-known limestone with huge Orthoceratites. In Gothland, the strata are exclusively upper Silurian (Wenlock); and of the wide tract in central Norway—the southern portion, near the Miosen lake, may, from its fossils, be of the same date. The rocks there, according to Keilhau, are chiefly limestone, with clay slate and greywacke, but in the more northern region, mica and chlorite slates abound, and no fossils are known, so that they seem more related to the crystalline strata. The unfossiliferous greywacke, near the North Cape, which we have not examined, has been considered Devonian, but is more probably Silurian.

In Russia, the older palæozoic, on the south shore of the Gulf of Finland, was shown by us to be chiefly lower Silurian, though beds full of upper Silurian fossils occur in Dago and Osel. The most ancient of these fossiliferous strata are remarkable as consisting of nearly unconsolidated mud, sand, and thin-bedded marly limestone, spread out in vast and almost horizontal sheets over a wide extent of country. In these undisturbed beds a continuous succession of organic life has been traced in one tract from the lowest strata, with their fucoids, to beds with fossils of true upper Silurian age. Passing below the newer formations in Central Russia, the older palæozoic again rises up along the western declivity of the Oural chain, and there seems chiefly upper Silurian, as shown by its fossils; but the strata are now highly inclined and hardened, and rest on mica slates, chlorite slates, and quartz rocks, which we regard as the metamorphosed equivalents of the lower Silurian on the eastern side of European Russia.—(See "Geology of Russia," p. 464, &c.)

In Germany, the older palæozoic of the Thüringerwald is in great part lower Silurian, based upon azoic, quartzose schists, and covered transgressively by Devonian, the intermediate upper Silurian being wanting. The rocks consist of greywacke, slates, and sandstone, with subordinate beds of limestone and alum slate, and in the lower portion contain numerous fucoid and annelid impressions; in the upper portion graptolites, orthoceratites, and some forms of trilobites. In Bohemia, M. Barrande has demonstrated a complete and symmetrical series of Silurian strata, consisting in ascending order of the following eight stages (étages), of which four correspond to the lower, and four to the upper Silurian of England, the lower division being by far the most extended, both in its superficial and vertical dimensions. The lowest division, A, is composed of talcose, chloritic, and other schists, resting below on granite.

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[1] Siluria, 1854, p. 361.

[2] Near Vichy—Quarterly Geological Journal, vol. vii. p. 13.

[3] See Murchison, Silurian System, 1839; Russia and the Ural Mountains, by Murchison, De Verneuil, and Keyserling, 1845; and Siluria, by Murchison, 1854.

These schists pass upwards into clay slate, and this, as we ascend, into greywackes or conglomerates, forming the second division B. Both these divisions are azoic, or contain no organic remains, and calcareous matter is also rare in them. The third division, C, is again fine-grained clay slates, or conglomerates, with a distinct group of organic remains, constituting M. Barrande's primordial fauna. In this, certain trilobites abound, as Agnostus, Paradoxides, Sao, and others, with some Cystideæ, and a few species of Orthis. D, the last and chief division of the lower Silurian, is chiefly quartzites, with schists and conglomerates, but still little limestone. In its fauna, trilobites typical of British rocks predominate, of the genera Trinucleus, Ogygia, Asaphus, &c.; and along with them pteropods, gasteropods, brachiopods, some rare fragments of orthoceratites; also crinoids, a few corals, and abundant cystideæ. Stage E, the bottom of the upper Silurians, begins with trap rocks intercalated in black graptolite schists, which pass up into dark grey argillaceous limestones, containing the richest fauna in the whole series. The species of trilobites are still numerous; the cephalopods suddenly assume an immense development, the gasteropods, acephalæ, and brachiopods (Terebratula, Spirifer, Orthis, Leptæna, &c.) increase rapidly; encrinites are in incalculable numbers, though of few species; and zoophytes also abound; many of the fossils being identical with British types. Stage F, a thin-bedded, hard, and often cherty limestone, shows a decreasing fauna, which continues, in the next stage, G, of compact, greyish, nodular limestone, in thicker beds; and in H, the highest group, of grey or yellow slates, animal life becomes exceedingly poor, compared to any of the inferior divisions. M. Barrande's section represents the whole in conformable unbroken order, whilst the succession of organic life is marked by a remarkable interchange of fossils. The general succession is, however, entirely in unison with that of Scandinavia and the typical regions of England.

In France, also, as seen in Brittany, a trace only of the upper Silurian occurs, and the older palæozoic belongs essentially to the lower subdivision. In the first recognisable fossiliferous beds (Llandeilo), trilobites abound, with a few molluscs; but these remains have less specific relations to those of Britain than to those of Bohemia and Spain. In the latter country, and in Portugal, Silurian rocks have again been found in great abundance, and also chiefly of the lower or older division. Our map, embodying many of the results of the researches of De Verneuil, D. Sharpe, Casiano de Prado, and others, shows the great development of these strata along the chief mountain-chains of the Peninsula—along the west coast of Portugal and adjoining region of Spain—on the flanks of the Guadarama—in the central regions north of Madrid—in the Sierra Morena, where they contain the long-celebrated quicksilver mines of Almaden—in the mountains of Toledo—and in wide extent in Murcia, on the east, being there rich in ores of lead and silver—as near Carthagena—and in the Sierra Almagrera. In Sardinia, also, General della Marmora has enabled us to lay down Silurian rocks containing fossils both of the older and newer types.

The eastern portion of our map shows a considerable extent of older palæozoic strata, though fossils of any kind have rarely been found in this region (upper Silurian at Dienten, in the Salzburg Alps). In some of these localities they are remarkable for rich masses of siderite; but, from the want of fossils, the age of such strata is often very uncertain. Further east, this group of deposits is scarcely known in this southern latitude, though it is not improbable that subsequent researches may show that they form portions of the mountain ranges of Turkey in Europe.

NEWER PALÆOZOIC GROUP.

In this group we comprise—*first*, The Devonian rocks, or old red sandstone, characterised in some places by peculiar fossil fishes—this class of animals now first appearing in abundance in the history of the earth—in other places where limestone beds abound by numerous shells and corals, which appear to have formed true reefs in these ancient seas; *second*, the Carboniferous rocks, including the mountain limestone, with its rich series of marine fossils, and the coal measures, with their numerous plants and valuable beds of fossil fuel; *third*, The Permian rocks, or upper group of red sandstones, also characterised by peculiar animal and vegetable remains, though these are less abundant than in the former strata.

In this group the class of reptiles first appears in the history of the earth, one small species, the Telerpeton Elginense, being found in the old red sandstone of the north of Scotland, two species of Archegosaurus in the coal of Saarebrück, and an allied reptile in the carboniferous beds of Lanarkshire; whilst in the Permian deposits they are still more numerous, and belong to a higher order.

The rocks of this group are best known in the north and west of Europe. In Britain, the succession from above downwards is the following:—

PERMIAN,
- Upper red marls.
- Magnesian limestone.
- Lower red sandstone.

CARBONIFEROUS,
- Coal measures.
- Millstone grit.
- Mountain limestone.

DEVONIAN,

Central England (Herefordshire).	*North Devon.*
Sandstones and conglomerates.	Upper limestone (Pilton and Petherwin.
Red and green marls, sandstones and cornstones.	Sandstones (Marwood).
Red marls and flagstones.	Quartzose schists.
	Ilfracombe schists and limestones.
	Red sandstones and schists (Linton).

In Rhenish Prussia and a small portion of Belgium, where the series of carboniferous and Devonian rocks is well developed, the coal-bearing strata are usually first underlaid by the "flötzleerer Sandstein," an equivalent of the millstone grit, and next by Possidonomya-schiefer and Kiesel-schiefer—occasionally indeed by limestone, which, with the above-mentioned schists, constitute the representative of the British mountain limestone. These strata are succeeded inferiorly by a greatly expanded tripartite Devonian group, in some tracts swelled out by great interlaminations of "Schaalstein," or volcanic ash. The upper part of this group is composed of Kramenzel-stein and Cypridina-schiefer; the middle Devonian is made up of the well-known Eifel limestone and its underlying Calceola-schiefer; whilst the lower Devonian consists of the Wissenbach and Caub slates, and the spirifer sandstone, or Coblentz greywacke; no true upper Silurian rock being anywhere visible. We do not here allude to the nomenclature of M. Dumont, because none of his divisionary lines, founded on lithological characters (not even his Terrain Rhenan), are consistent with our classification as established upon the distribution and classification of former life.[1]

In reference to geographical distribution, our map shows that these deposits are chiefly developed in the north and west of Europe. They cover four-fifths of Ireland,—the Devonian and lower or unproductive carboniferous strata occupying the widest spaces, whilst the coal measures and Permian are more restricted in their range. In Britain, they form a broad band in the centre of England, running from Devonshire to the south of Scotland, and presenting the full succession given above. In Scotland, the Permian formation is not known, though some of its newer red sandstones may yet prove of that age; and in the north of that country only the lower beds, or old red sandstone, full of its singular fishes, are seen, resting unconformably on the crystalline schists. The former wide extent of this formation is shown by the fragments found spread at intervals over the mainland of Scotland, from Aberdeen to the west coast of Inverness and Sutherland, and in the Orkney and Shetland Islands, and by the red sandstones and conglomerates to which the same age must be assigned, on the west coast and in the centre of Scandinavia. In Russia, these formations have a greater extent than in all the rest of Europe conjoined; but the upper and lower divisions chiefly occur, to the exclusion of the central coal-bearing strata. The Devonian formation extends on its south border from the Gulf of Riga to Voroneje and the Don, and on the north-west side in a broad band to Archangel and the White Sea, reappearing in the Timan Mountains, and in narrow bands on the western slopes of the Oural. Within these ranges the carboniferous rocks, with scarcely a trace of coal, spread out in the broad dome-like plateau where the Don, Dnieper, Duna, and Volga have their rise, and run north in a narrower band to the mouth of the Mezene river on the White Sea, whence they may be traced, though beyond the limits of our map, to Bear Island and Spitzbergen in the far north. They again bound the chain of the Timan and Oural Mountains, though in narrower bands, being everywhere overlaid by the next, or Permian formation, which has an enormous development, not only in the province whence one of us took its name, but also in the north-west, throughout the whole upper basin of the Dvina. In the south of Russia, on the lower course of the Don, this group again appears, and here consists of carboniferous strata, with coal-beds wrought to a considerable extent.

The western margin of this group, in France and Belgium, consists of true coal-measures, sometimes associated with, sometimes underlaid by, mountain limestone, and analogous to the coal-fields of Britain. These deposits in central France present a different character—the mountain limestone being wanting, and the coal, formed in small basins amid the crystalline strata, occurring in thick irregular beds, characterised by Palæonisci and other small fishes. The great mass of the strata extending from the Ardennes and Eifel to the north bank of the Rhine, is, however, of Devonian age, with limestones full of the characteristic molluscs and corals, and in part covered by carboniferous deposits. The sedimentary formations in the Harz mountains consist chiefly of Devonian rocks (lower, middle, upper)—though a certain portion of these to south-east, near Harzgerode, must be termed uppermost Silurian. In that region, however, the formations are so highly dislocated that no physical order can be well followed out. Large tracts certainly pertain to the lower carboniferous strata, particularly around the mines of Clausthal, where the inversions and fractures are most remarkable. This fragmentary chain, so pierced by granites and various intrusive rocks, is to a great extent surrounded by a zone of Permian rocks—which in the south-eastern tract consist of a vast thickness of Rothe Todte Liegende, Kupfer-schiefer, and Zechstein, and an overlying red sandstone—these constituting, as in Thuringia and many other parts of Germany, a lower "Trias." The red sandstone, which constitutes the base of this group, has been pierced, near Eisenach, to a depth of 2000 feet in search of coal, and this is exclusive of 800 feet of powerful conglomerates with psaronites; then follows the "Kupfer-schiefer," which, though only a foot or two thick, has afforded so much copper and silver; and next the Zechstein, with its dolomites and gypsum, the equivalent of the English magnesian limestone. Lastly, the Permian group is completed by an overlying red sandstone, often very earthy and marly, containing (though very rarely) calamites. In central Europe true coal and Devonian deposits are well known in Silesia and Moravia; but, farther to the east, have only been recognised in a few points—as the Devonian near Grätz, and the lower carboniferous near Bleiberg in Carinthia.

South of the Alps this group has been only recently detected in the north of Italy, in Tuscany, but more fully in Sardinia, where true coal-plants have been found. In Spain, the Devonian is very fully represented, the mass of the palæozoic formations of the Pyrenees being of this age, though older fossils also occur. The great chain of the Sierra Cantabrica also consists, in its central portion, of Devonian strata, overlaid on the east by the richest coal-field in Spain. Coal is again known in Portugal, and both carboniferous and Devonian rocks occur in the Sierra Morena. In southern Europe (including the Alps) no Permian deposits are known, all the newer red sandstones of the Iberian peninsula being probably of triassic age.

After a long interval, true Devonian strata again appear in abundance in Asia Minor. They are well known on both shores of the Bosphorus, and, according to M. Tchihatcheff, form many of the most important mountain-chains as far east as the Taurus. Beyond this they have been observed on the flanks of Mount Ararat by Abich, and in several places on the shores of the Caspian; also in the Taurus Mountains, at Erzeroum. Carboniferous strata, abundantly charged with fossils and coal, occupy many miles of the southern coast of the Black Sea near Eregli. Though now largely worked for the purposes of the war, they have hitherto almost escaped the notice of geologists. In these regions no Permian strata have been discovered.

MESOZOIC GROUP.

In this group are comprised the Trias, the Jura, including both the lias and oolite, the Wealden, and the Cretaceous strata. The Trias is best known in Germany, where its central group, the muschelkalk, with its underlying "bunter sandstein," and its overlying "keuper" are most fully developed; and where it is remarkable in containing the Nothosaurus, Mastodonsaurus, Trematosaurus, and other Labyrinthodont species (H. von Meyer), as well as a profusion of marine shells entirely distinct from those even of the youngest of the palæozoic formations. In England the sandstone beds only appear, and hence the term Trias seems inapplicable. From the south-west of Germany it extends into the east of France and Switzerland, and is well known on both flanks of the Alps, as red sandstones, limestones, and dolomites, often associated with quartzose porphyry. In the eastern portion of the chain, it contains in its uppermost band the remarkable beds of St Cassian, celebrated for their peculiar assemblage of fossils—and strata of the same age have been recently recognised in several other places. In southern Germany and France, the Trias is rich in mines of rock-salt; in Silesia, some of the dolomitic limestones contain abundant ores of zinc, but are very poor in organic remains. In Southern Europe, the Trias is most developed in Spain, where it has been recognised in many places by De Verneuil and others, though chiefly as red sandstones. The central limestone, so characteristic of the formation in Germany, was considered wanting; but we have sincere pleasure in announcing that our distinguished friend De Verneuil discovered it last year, with its characteristic fossils, in several of the provinces.

The second member, or Jura, including the lias and oolitic series, far surpasses the Trias both in geographical extent and in the number and variety of its organic remains. Of these, more than four thousand species are known in this formation, differing not merely in the species but in the genera from the palæozoic races. The trilobites, and most of the peculiar genera of brachiopods and fishes, have disappeared. New races of Echinoderms, especially of echinidæ, now abound: of the old cephalopods only the Nautili remain, whilst the Ammonites appear in very numerous forms: decapod crustaceans also now appear, though chiefly the macruri; and though osseous fishes are still wanting, yet true chimæroid fishes, ganoids with homocerc tails, including numerous genera of Lepidoids and Sauroids, with the Pycnodonts, distinguish this formation from the former. The numerous reptiles, especially gigantic Saurians, crocodiles, and the first Chelonians, also characterise this period in the earth's history. The numerous alternating thin beds of dark clays and limestones, often of an oolitic texture, indicate deposition in an open sea, subject to little disturbance.

In England, this formation ranges from the south coast through the centre of the country to Yorkshire on the east coast. After a long interval it reappears in the north of Scotland, at Elgin, Brora, and in the Western Isles. These fragments, connected with the similar strata in the north of Ireland, and with a few traces in Faröe and Iceland—where the fine double refracting calc-spar seems to belong to an altered bed of this formation—indicate a much wider extension of the Jurassic deposits in this region, now either buried below the ocean or destroyed by its waves, except where they have been protected by the harder masses of trap rocks poured out over them. With this basin we may conjoin the beds known in Scania, in the south of Sweden. In the extreme north of Russia it fills, according to Keyserling, the desolate valley of the Petchora river, and thence extends south, along the watershed dividing the rivers that flow into the White Sea from the affluents of the Volga. Jurassic beds (dark Oxfordian clays), full of ammonites and other characteristic fossils, with remains of fishes, ichthyosauri, and other reptiles, are common near Moscow. In southern Russia, in the Crimea, rising up in the mountain ranges between Kaffa and Sevastopol, and on both sides of the Caucasus, rocks of this age are well known, but characterised by species of fossils in a great part distinct from those in the north of the same region, showing that a diversity of climate now prevailed in this part of Europe. It is truly remarkable that the Oxfordian member of the Jurassic system, which is so largely developed in Russia almost to the entire exclusion of the inferior members and the Lias, should range into the heart of Asia, and be the characteristic rock of that age in Northern Hindostan and the Himalaya Mountains!

In Central and Western Europe, this formation is also very fully developed, having apparently been deposited in an ocean on the shores of a large island or peninsula, extending east and west from Bohemia to Belgium, and formed of the older strata lately mentioned. Of this island, the Jurassic rocks in Westphalia and Poland formed the northern shore; its western margin was bounded by the basin in which the Jurassic beds of England and France were laid down; whilst on the south and east it extended continuously through the region now occupied by the Alps, which then could have had a partial existence only, into Italy, Dalmatia, and probably even more remote regions. In the Jura mountains, whence the formation is named, the lowest bed resting on the trias is the lias, consisting below of sandstones and limestones, with abundance of the Gryphæa arcuata, and above, of marls, with numerous Ammonites and Plicatulæ. On this follows the lower Oolite, consisting of a ferruginous oolite, compact limestones with few fossils, and of other limestones and marls with Ostrea acuminata. The middle Oolite, again, is composed of marls representing the Oxford clay, and an upper bed full of peculiar concretions of ochrey clay (Terrain à chailles) with many amorphozoa, cidarites, and other fossils. The upper group consists of the coral limestone, with Diceras arietina, Ostreæ, many cidarites and crinoids, of marls with Melania, Mytilus, and Astarte; another limestone, with cidarites and crinoids; then marls and limestones, equivalent to the Kimmeridge clay of England; and a higher group, also of marls, with Exogyra and Lyriodon, and limestones with Nerinea and Turbo, which represent the Portland stone. In the Alps this formation also appears, but the strata so broken and contorted by the subsequent upheaval of that vast chain of mountains, and so distinct, both in lithological and palæontological features, that little more than the parallelism of the great leading divisions with those of Western Europe can be recognised. In this region the originally horizontal beds are now often reversed in position, raised up into enormous mountains, and, as already stated, are in many places highly crystalline. The Jura in France forms two connected circles, one nearly enclosing the tertiary basin of Paris, and connected with the English strata, the other round the crystalline rocks of the centre. In this country, as in England, the well-known dark-coloured marly and arenaceous clays, and blue or grey limestones of the lias, form the base of the formation, covered by the lighter-coloured oolitic limestones, separated from each other by intermediate bands of clay. In the south of Europe the Jura formation is well seen in Spain, especially on the Mediterranean coast. In Italy it forms some of the higher parts of the Apennines, but has not been well separated from the overlying cretaceous strata. This separation is still more uncertain in Turkey in Europe and Greece, though both in these countries and in Asia Minor the cretaceous, or even newer formations, appear to prevail.

In the south-east of England, in some neighbouring parts of France, in Hanover, Westphalia, and a few other localities, the Jurassic beds are followed by the series of fresh-water deposits named the Wealden. In England and Germany a threefold division of these strata into the Purbeck beds, Hastings sands, and Weald clay has been recognised. In Hanover, where the formation consists especially of clays and marls, with subordinate beds of sandstone and limestone, it is remarkable for containing coal and iron-stone of sufficient value to be wrought (Bückeburg). The iron ore is an argillaceous carbonate, in rounded concretions, occasionally forming continuous layers. Of the coal, from sixteen to twenty beds are known in the Osterwald. Among the vegetable remains are six species of Sphenopteris, nine of Pecopteris, four of Cyclopteris, two of Cycadites, and three of Thuites; in the animals, there are five species of Unio, thirty-seven of Cyrena, four of Cyclas, nine of Melania, eight of Paludina, and eight of Cypris, with several fishes, saurians, and tortoises. The fossils of these deposits are, however, chiefly distinct from those of the marine formations above and below, leaving their connection doubtful,—some geologists uniting them with the Jura, others with the chalk.

The highest group in this series, or the Cretaceous, is named from the white earthy limestone or chalk which prevails in it in England, France, and parts of Germany and Russia, and which seems almost peculiar to this period of the history of the earth. But this lithological character is very fugitive, and has led to considerable mistakes. Thus, for example, strata containing precisely the same fossils which in Russia on the east, and in Britain on the west, characterise masses of pure white chalk, are found in fine silicious sandstones (obrer Quader of the Elbe) near Dresden. This "obrer Quader" is the equivalent of the uppermost or flinty chalk of Britain. The "pläner Kalk" of this tract, a marly, sandy, and very impure limestone, mineralogically undistinguishable from the British upper greensand or "malm rock," is still an integral portion of the white chalk formation; whilst the "Untrer" or lower quader sandstone, which for a long time passed current for our lower green sandstone, is clearly (from its very numerous fossils) the exact equivalent of our lower chalk-marl, &c.

Again, in parts of Northern Germany, where the Cretaceous rocks are thrown into vertical mural masses, and often inverted (northern flank of the Harz), mere lithological characters might strangely mislead an English geologist; for the only white chalky rocks near Goslar are of older tertiary age, whilst the true representations of the chalk (as in Saxony) are light-coloured silicious sandstones (Teufel's Mauer, &c.) In Northern Germany a zone of clay representing our gault is occasionally visible, but in other places the fossils of this age occur even in a red sandstone (east of Paderborn). On the whole, the grand triple formation of the lower greensand of Fitton, which we have ourselves particularly examined, is most imperfectly represented on the Continent, *i.e.*, in its upper and central masses (ferruginous and lower greensands). Its lower member, which with us is well seen in the Atherfield rocks (Isle of Wight), expands, however, into an important formation in Northern Germany (Hils Bildungen and Conglomerat), and into great crystalline limestones in the Alps. The upper member of the cretaceous group is rich in organic remains, sponges, foraminifera, polypifera, radiata, (marsupites, ananchytes), brachiopods, and fishes. With this formation the secondary or mesozoic group terminates, the boundary between it and the tertiary deposits being strongly marked by the complete disappearance of the ammonites, belemnites, nerinea, exogyra, the cestraciont and hybodont fishes, and many genera of animals. It is not less marked by the commencement, in the superior deposits, of the mammalia, birds, serpents, true batrachians, and many groups of radiata, molluscs, and fishes.

The geographical distribution of the cretaceous strata is remarkable, as in this group the influence of the present isothermal lines is regarded as first clearly shown. In the British Islands, Flamborough Head in England, the north of Ireland, and some fragments in Aberdeenshire in Scotland, are its northern limits. It is then seen at Thisted in Jutland, and in the south of Sweden. Following it into Russia, it descends much further south, conformable to the present course of the isothermals, till in the eastern part of our map it does not extend north of the basin of the Caspian, and thus far south of the arctic boundary of the Jura, though it appears very fully developed both on the south declivity of the Caucasus and in Asia Minor. Indeed, both in the south and east of our map it appears to occupy a more important place than in the west or north.

TERTIARY GROUP.

In this group we comprise all the deposits superior to the chalk, however varied in mineral composition, and whether formed in the sea or in fresh water. Its inferior limit towards the chalk has recently undergone considerable change,—a great portion of the nummulite rocks of the Carpathians, Alps, and Italy having been classed with the older series previous to the recent publication of a memoir on these regions.[2] In this memoir it was shown that the great group of strata characterised by the presence of this peculiar organism, and which prevail so extensively in Southern Europe, and extend from the basin of the Mediterranean, through Asia Minor and Syria, even to the foot of the Himalayas, belong not to the chalk but to the tertiary group. As this rectification of the position of the nummulite rocks has not yet been fully carried out on maps, particularly in Italy, Turkey, and some other parts of Eastern Europe (though M. Studer has adopted it for Switzerland), the boundaries of the cretaceous and tertiary groups are so far uncertain.

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[1] See Table of Comparison with Dumont's names—"Siluria," p. 382.

[2] See Murchison on the Alps, Apennines, and Carpathians—Quarterly Geological Journal, vol. v., p. 157.

Our map shows that, as the older strata prevailed in the north of Europe, so the centre and south have most recently emerged from the waters. From the south of England, tertiary strata extend almost continuously through Northern Germany and Russia to the shores of the Black Sea and Caspian. In the southern part of the map, also, all the great rivers, almost without exception, flow through basins of tertiary strata—and large portions, even of the loftiest mountain-chains, are formed of the same deposits. These formations, however, are of widely different age; and great diversity prevails, both in their mineral character and organic remains, as we pass from basin to basin and country to country. In respect of age, two distinct groups may be recognised—an older, including the eocene and more ancient miocene, and a newer, including the higher miocene, the pliocene, and more recent deposits. These two groups show very distinct characters, the flora and fauna of the older group being entirely distinct from that of the newer, throughout which great similarity prevails. There are but few species common to the two groups, and even the genera of mammalia and plants are for the most part distinct. Of the species in the older group, very few have continued to live on to recent times; and it is specially characterised by the nummulites of the sea, the palæotheres, anoplotheres, lophodons, and allied mammals of the land. In the upper group, not only do living species more abound, but we find also greater approximation to the present climatal conditions of the locality. Thus, in the mammalia, there are not only the extinct deinotheres and mastodons, but species of elephas, rhinoceros, and sus; and in the vegetation, trees of the families of Laurineæ, Acerineæ, Amentaceæ, and Juglandeæ. In this small map we have not attempted their division; but would generally include in the former the greater part of the beds in the London basin, in the Isle of Wight and Hampshire, in the Paris basin, Belgium, North Germany (where London clay fossils have been found close to Berlin), of Poland, and portions of Southern Russia. In the south of France they fill the valley of Languedoc and Provence, covered in the centre by the newer series, and skirt both flanks of the Pyrenees. They also form great deposits, often in a *quasi* crystalline state, within and along the flanks of the Alps, and in the Apennines rise to some of the loftiest summits. On the opposite shore of the Adriatic, nummulite rocks, or older tertiary, are also well known; and in Asia Minor and Syria, where still but imperfectly separated from the chalk, cover wide spaces, and rise to great elevations. For the newer series, we shall only refer to some portions of the shores of the North Sea, the river-basins of the Rhine, Po, and Danube, some parts of the coasts of Italy and Sicily, and the great Aralo-Caspian depression.

A most important distinction in these beds has reference to the place where they were formed. Some deposits have taken place in the ocean or salt water, others in fresh-water lakes of more or less extent. In Northern Europe, beds of marine origin seem chiefly to prevail, though fresh-water deposits are also well known both in England and in France. In Auvergne, the formations are entirely fresh water; on the Rhine and in Switzerland vast fluviatile deposits abound. The upper tertiaries in Austria, Hungary, Tuscany, Greece, and Asia Minor, are also often fresh-water deposits. Spain, however, probably shows larger formations of this nature than any other part of Europe,—the great tertiary basin of the upper Douro, between Salamanca, Leon, Burgos, and Segovia, the central valley of the Ebro, and the not inferior basin of the Tagus, between the Guadarrama and Sierra Morena, being the remains of ancient lakes. In Murcia, near Seville, and the south, the tertiaries, on the other hand, are chiefly marine, whilst at Lisbon marine beds overlie the fresh-water deposits.

In connection with the more recent deposits, we have also inserted on the map the line marking the most southerly distribution of huge, northern erratic blocks derived from the Scandinavian mountains. These are most remarkable for numbers and size in the German plains south of the Baltic; but similar transported stones are found on the coasts of Scotland, and as far south as Yorkshire. Full collections of the characteristic rocks and fossils of Sweden have even been made in Northern Germany.

IGNEOUS ROCKS.

Of these we have formed three groups,—the first including the granites, syenites, and a few other crystalline masses closely connected with them; the second including the porphyries, diorites, dolerites, basalts, and other so-called trap rocks of the British Isles; whilst the third contains the products of extinct or active volcanoes, and some of the trachytes and other igneous rocks whose volcanic nature is best established. Though no very precise lines of division, either from mineral composition or period of production, can be drawn between these formations, still the marked distinctions between the extreme members of each group appeared to render it important to endeavour to distinguish them.

The classification of the igneous rocks depending chiefly on their mineral character, only partially corresponds to that of the stratified rocks, based on entirely different considerations. Hence, though in general the granites are more frequently associated with the crystalline schists and older palæozoic, the trap rocks with the newer palæozoic and mesozoic, and volcanic eruptions with more recent deposits, still exceptions are very numerous. The geographical distribution of these igneous rocks is also remarkable. The larger masses of granite range along the western or Atlantic shore of Europe, from Spain and Portugal, through central France and Brittany, Ireland, and Scotland, to Scandinavia and Finland. The Riesengebirge and Erzgebirge in Saxony, with the Böhmerwald and Moravian mountains, form another extensive granitic mass, highly influential on the physical peculiarities of the European continent. The granite in other portions of our map, in the Alps, Carpathians, and Oural, in Corsica, Sardinia, Southern Italy, and Turkey, appears less important either in extent or influence.

The trap rocks are also most abundant in the western portion of our map, especially in the northern portions of the British Islands. In this region they sometimes form large tabular masses overlying the stratified rocks, as in the north of Ireland, the Hebrides, Faröe, and Iceland, or mountain ranges of considerable extent, as in the centre and south of Scotland. In Scandinavia similar rocks occur, often so richly impregnated with iron as to be used for ores of that metal. Similar relations are known in the Oural, whilst the entire absence of igneous rocks of any class is a remarkable characteristic of the great plains and unbroken sedimentary deposits of Central Russia.

The basalts, trachytes, and associated igneous products in Germany and Hungary, are often more intimately connected with our third division of volcanic rocks. Of these, two classes may be formed according as they are connected with extinct or still active volcanoes; but the distinction is less essential than might at first appear. The most remarkable of the former division are the Eifel, Siebengebirge, Westerwald, Vogel's, and Rhön-Gebirge in western Germany; the vicinity of Carlsbad, and Schemnitz; Eperies, Tokay, and parts of the Carpathians; in France, Auvergne, the Cantal, and Vivarais; in Spain, the vicinity of Olot in Catalonia. In Italy and its islands both classes abound; and this is also true of Iceland in the remote north-west, of Asia Minor and the Caucasus in the extreme south-east of our map. Of volcanoes that have been active in historic times, the best known are the Icelandic group (above twenty in number), Vesuvius, Etna, and the connected vents in the Lipari Islands.

In examining the map, perhaps the most remarkable feature in regard to these igneous rocks is the very limited space they occupy on the surface, even in the most mountainous regions. Thus, the granite generally covers but a small space compared to the associated crystalline strata, and the other igneous rocks appear in still more limited masses. Their importance, in other respects, is however very great, marking out, as they do, the most important mountain ranges, and giving rise to those changes during which the rocks have become filled with rich mineral veins. In reference to these rocks, we need scarcely mention that the scale of our map has not permitted us to mark the many detached veins or dykes which occur in various countries.

INDEX OF EUROPEAN ROCKS.

The following alphabetical list is intended chiefly as an explanation of the names of some remarkable European formations which have not been mentioned in the previous notes:—

ALBERESE. Marly calcareous beds, with fucoidal impressions in Tuscany, where they belong to the upper Eocene.

ALLUVIUM. Beds deposited in historic times by springs, rivers, or lakes.

ALPINE LIMESTONE (*Alpenkalkstein*, German). Limestones common in many parts of the Alps, and now classed partly with the Trias, partly with the Jurassic rocks.

ALUM SLATE (*Alaunschiefer*, German). Black carbonaceous clay slates, often containing much iron pyrites, and producing alum on decomposition. They are common in the Silurian rocks of Scotland, where they often contain graptolites, and of Wales, Sweden, Saxony, &c.; also in the coal-formation and Jurassic rocks, as at Whitby.

AMMONITICO ROSSO. A red coloured limestone in the Italian Alps, shown by its fossils, Ammonites tatricus, athleta, anceps, Terebratula diphya, and triangulus, &c., to be an equivalent of the middle Jura.

AMPHIBOLITE. Hornblende rock.

ANAMESITE. A fine-grained variety of dolerite, well seen at Steinheim, near Hanau.

ANTHRACITE FORMATION. A group of strata containing true carboniferous plants, associated with strata containing belemnites and other lias fossils, known in the Maurienne, the Tarantaise near Briançon, and in other parts of the Alps of Oisans. The true explanation of the phenomena seems to be found in the violent contortion and squeezing together of beds of different age.

APENNINE LIMESTONE. Limestone forming the chain of the Apennines in Italy, now ascertained to be of very diverse age, some portions Jurassic, others cretaceous, and others, in which nummulites occur, older Tertiary.

APHANITE. A very fine grained, apparently compact, igneous rock of the trap formation, generally of a dark-green colour, and occasionally a compact Diorite with hornblende, or Dolerite with augite.

ARALO-CASPIAN. A term proposed by Murchison and his associates to mark the fact, that the fossiliferous rocks of an enormous area around the Caspian and Aral, contain exclusively the remains of animals (fresh water and brackish) which are now peculiar to those seas.

ARGILE PLASTIQUE. Plastic clays and marls, with lignite and fluviatile shells, found in the lower Tertiary of the Paris basin.

ARKOSE. A sandstone of felspar and quartz. Occurs in the coal-formation in Scotland, in the Trias in Germany, and the Lias in France.

ÅSAR. Long mounds of detritus in Sweden and Norway. In Ireland similar mounds are named Eskar; in Scotland, often Kaims.

AUGITE ROCK. A dark green, grey, or black crystalline rock, consisting essentially of augite. It is found near Lherz, in the valley of Vicdessous in the Pyrenees, and from this place is sometimes named Lherzolite.

AYMESTRY LIMESTONE (Murchison). A grey sub-crystalline argillaceous limestone, forming the central portion of the Ludlow formation in the Upper Silurian of England.

BAGSHOT SANDS. Beds of siliceous sands occurring near Bagshot in Surrey, and containing marine shells, which form part of the lower tertiary.

BASALT. An apparently uniform, compact, dark grey, or black rock, composed of augite and labradorite, with magnetic iron and olivine. Belongs to the trap or volcanic family, and is common in Scotland, Hessia, Saxony, Bohemia, in the Eifel, Auvergne, and other regions.

BERESITE. A peculiar granite, containing gold veins, named from Beresowsk in the Oural, where it occurs.

BIANCONE. A white compact limestone in the Venetian Alps, containing Crioceratites, Inocerami, and Echinoderms, of lower cretaceous age.

BOLCA LIMESTONE. A thinly-laminated compact limestone of the tertiary period, remarkable for its numerous remains of fossil fishes.

BRADFORD CLAY. A local formation, lying on the Great Oolite in Wiltshire.

BRANDSCHIEFER (German). Very carbonaceous slate clays, or impure argillaceous coals, found both in the carboniferous and brown coal formations.

BROWN COAL (*Braunkohlen*, German) **FORMATION.** Thick masses of brown coal or lignite, characterised by its brown colour, brown streak, and ligneous texture; found intermixed with clays, sands, and sandstone in many parts of Germany, especially in Hessia, Saxony, Franconia, and Bohemia. It contains much wood, often half fossilised by pyrites—also impressions of plants, fishes, and frogs, and belongs chiefly to the older tertiary period.

BUNTER SANDSTEIN FORMATION. The Grès bigarré of the French, the lower portion of the New red sandstone of England; is the lower member of the trias. Its name is taken from the variously coloured sandstones and marls of which it consists.

CALCAIRE GROSSIER (*Grobkalk*, German). A coarse sandy limestone, containing very many fossil shells, in the lower tertiary of the Paris basin. It forms the material of which that city is chiefly built.

CAPROTINA LIMESTONE. A member of the cretaceous formation in the Alps.

CARADOC SANDSTONE (Murchison). The upper member of the Lower Silurian of England.

CARBONIFEROUS LIMESTONE (*Kohlenkalkstein*, German; *Calcaire carbonifère*, French; mountain limestone, or Bergkalk, of some authors). A limestone, with marine shells and corals, forming the chief lower member of the carboniferous rocks. It is most fully developed in the British Islands, Belgium, and some neighbouring parts of France and Germany.

CARPATHIAN SANDSTONE. Sandstones of various age have been confused under this term; one of the most important is that which, with shales, marls, and gypsum, contains the salt-mines of Wielicka, and other places on the northern side of the Carpathians. It is the equivalent of the Vienna sandstone, and of upper tertiary age; another is of lower cretaceous age.

CASSIAN (St) BEDS. A group of red sandstone, limestone, and dolomite beds, found near St Cassian in the Tyrol, near Recoaro, Hallstadt, and many other parts of the Eastern Alps. They are said to contain orthoceratites, ceratites, and ammonites, conjoined in the same bed, and are now considered as the equivalents of the upper Trias.

CHLORITE SLATE. A dark-green slaty rock, composed chiefly of chlorite, with some quartz and felspar. It is not uncommon in the crystalline strata in the west of Scotland and in Tyrol, and is remarkable for the many beautiful minerals it contains.

CIPOLLINO. Granular limestone, mixed with mica, common in the crystalline strata of many parts of Europe.

CLYMENIA LIMESTONE. A portion of the Devonian formation known at Petherwin, Devon; near Saalfield in Thuringia; Elbersreuth near the Fichtelgebirge; the Rhenish provinces of Prussia, and other places.

CORAL-RAG. A member of the middle oolite of England, named from the numerous remains of corals it contains.

CORNBRASH. A portion of the lower oolites in England.

CORNSTONE. Beds of red or greenish concretionary limestone, found in the Old red sandstone, or Devonian formation of England.

CRAG. Upper tertiary beds of sand and pebbles, found in Suffolk, and containing many remains of marine animals. It is divided into the Coralline and Red crag. The Norwich Crag is a more recent group of fluvio-marine origin.

CYPRIDINA SLATES. An upper member of the Devonian formation of Germany.

DEVONIAN SYSTEM, or OLD RED SANDSTONE. The lowest formation of the Newer palæozoic group.

DIABASE. A fine grained crystalline mixture of augite and albite or labradorite, and thus equivalent to many of the greenstones in the coal-formation of Scotland (Salisbury Crags, &c.) Common also in the Harz and other parts of Germany.

DILUVIUM. Older detrital deposits, formed by causes not now acting in the locality.

DIORITE. A granular compound of hornblende and albite, usually of a dark-green colour, belonging to the trap family.

DIRT-BED. Earthy beds alternating with compact strata, especially known in the Purbeck wealden.

DOGGER. Synonyme of the lower oolite, in some parts of Germany.

DOLERITE. Granular crystalline mixture of labradorite and augite; almost always with some magnetic iron ore. Is dark green or grey, and then named Graustein (greystone.) Variety of trap.

DOLOMITE. Consists essentially of carbonate of magnesia (dolomite, or bitter spar), but often mixed with carbonate of lime. Very abundant in many parts of the crystalline, palæozoic, and mesozoic formations, and especially in the Permian formation, and in the Trias of the Alps.

DOMITE. A fine granular, or rough, earthy, and friable variety of trachyte, of grey, brown, or yellow colours, found especially on the Puy de Dome in Auvergne. Volcanic.

DRIFT. The term now usually substituted by English geologists for Diluvium, as implying no hypothesis.

DUDLEY LIMESTONE and SHALE. Equivalents of the Wenlock beds in the upper Silurian. Remarkable for fine corals, trilobites, and other fossils.

ECLOGITE. Green crystalline horneblende (or diallage), with garnet. Closely related to the greenstones or trap rocks. Occurs in the Sanalp in Styria, in the Fichtelgebirge, and Grecian Archipelago.

ELVANS. Veins or dykes of red felspar porphyry, in the clay-slate (Devonian) and granite of Cornwall.

EOCENE. Sir Charles Lyell's name for the older tertiary, in which four per cent, or under, of recent species occur.

ERRATIC BLOCKS. Large rounded or angular masses of stone, found at a distance from the place where the rocks from which they are derived occur. Known in the upper tertiary or diluvial deposits. In Europe the chief centre of dispersion has been from the north, Scandinavia and Finland. See MAP.

EUPHOTIDE. Synonyme of Gabbro.

EURITE. A fine scaly mixture of felspar and quartz, sometimes with a few distinct crystals of quartz or hornblende. Named from its easy fusibility. Occurs in Scotland, the Harz, and Brittany.

FAHLUNS OF TOURAINE. Beds of sand and marl, with many marine shells, in the basin of the Loire; belong to the Miocene or newer tertiary group.

FELSPAR PORPHYRY. Consists of a basis of compact or crystalline felspar, with crystals of orthoclase or albite; occasionally also of quartz or hornblende. Common in the Silurian rocks of Scotland, Cumberland, Wales, &c., and in the crystalline schists of Scotland, Scandinavia, and other parts of Europe.

FLÖTZLEERER SANDSTEIN. A term of the Prussian geologists for the equivalent of the British millstone grit.

FLYSCH. Dark-coloured slates, sandstones, impure limestones, marls, and breccias, with impressions of fucoids, Chondrites intricatus, and C. targionii. Common in many parts of the Alps, and equivalent to the nummulite or lower tertiary.

FULLER'S EARTH. One of the members of the English oolite in Wiltshire.

GABBRO, or EUPHOTIDE. A coarse granular mixture of labradorite and diallage, or hypersthene; occasionally with mica, garnet, or iron pyrites. Belongs to the greenstones or trap family.

GALLESTRO. A marly rock of distinct slaty friable texture, and striped of red, green, bright brown, or other lively colours. Occurs in the Apennines, often near igneous rocks. The Galestrini slates of Tuscany belong partly to the lower Eocene, partly to the upper chalk.

GAULT. Dark-blue clays or marls, lying between the lower and upper greensand in the cretaceous system of England.

GLARUS SLATES. Dark-coloured slate clays, with many impressions of fish, remains of a bird and tortoise. Classed by Agassiz as chalk, but since shown by one of us to be lower tertiary, or Eocene.

GNEISS. A granular mixture of felspar, quartz, and mica, with a distinct slaty texture. One of the chief constituents of the crystalline or metamorphic group of strata.

GOSAU FORMATION. Various sandy, marly, and calcareous rocks, in the valley of Gosau near Salzburg, and other parts of the Alps. It contains hippurites, corals, tornatella, and other chalk fossils.

GRANITE. Granular crystalline mixture of felspar (orthoclase and oligoclase, more rarely labradorite or albite), quartz, and mica; often contains hornblende, tourmaline, garnet, or other minerals. Very common in every part of the earth.

GRANULITE. A fine-grained scaly mixture of felspar, with a little quartz, and occasionally a small proportion of mica. It seems often a variety of gneiss.

GREENSAND. Lowest member of the English cretaceous strata.

GREENSTONE. General designation for the distinctly granular hornblende and augite rocks of the trap family, including diabase, diorite, dolerite, and others.

GREYWACKE. Grey-coloured rock, composed of grains or fragments of quartz, clay slate, flinty slate, and scales of mica, in a firm argillaceous basis. It is a very common rock in the older palæozoic formations, as the Silurian of Britain, Scandinavia, &c., and in the Devonian of the Rhine. The Germans sometimes name the whole lower palæozoic formations Grauwacken Gruppe.

GYPSUM. Sulphate of lime, in a more or less pure state. Occurs either in veins or beds, the latter most common in the mesozoic group of strata, as in many places near the foot of the Harz, in the Thüringerwald, in Switzerland and Tyrol.

HASTINGS SANDS. Lower member of the English Wealden.

HEADON SERIES. Sands, clays, and fresh-water limestones, in the lower tertiary of the Isle of Wight.

HILSFORMATION. German synonyme for the lowest cretaceous beds, the Neocomien or lowest greensand.

HIPPURITE LIMESTONE. Limestone containing many hippurites; common in the south of Europe, and on the shores of the Mediterranean. It there represents the chalk of Northern Europe.

HORNBLENDE ROCK. Granular hornblende with a little felspar, a variety of greenstone or trap.

HORNBLENDE SLATE. Rock composed of crystalline hornblende almost alone, with a schistose or laminar structure. Often passes into mica slate.

HYPERSTHENE ROCK. Granular mixture of hypersthene and felspar, found in the Isle of Skye and in the Harz.

JURA FORMATION. Synonyme of the Oolite (including the Lias) formation.

KARST LIMESTONES. Limestone rocks of grey, yellow, or brown colours, and containing many remarkable caves, which form the Karst mountains between Leybach and Triest. The lower beds contain hippurites, and belong to the chalk; the upper masses, with many nummulites, are older tertiary.

KELLOWAY ROCK. A member of the English oolites.

KEUPER. Name of a fine-grained grey sandstone in Franconia, forming part of the Upper Trias. From this bed the term has been extended to the whole formation.

KILLAS. Provincial name for the coarse argillaceous slates in Cornwall.

KIMMERIDGE CLAY. Bituminous clays and marls in the upper part of the English oolites or Jura formation.

KUPFERSCHIEFER. A dark or black coloured, bituminous marly slate, with numerous impressions of fishes and fucoids, forming the base of the Zechstein. It is one member of the "Permian" of Germany, and is there extensively mined for the disseminated copper ore it contains.

LAVA. General term for rocks that have flowed in a molten state from volcanoes whatever their nature or composition.

LEHM. German name for impure clay beds, coloured yellow by the oxyhydrate of iron, and belonging to the most recent formations.

LEITHA LIMESTONE. Limestone of the Leitha hills near Vienna, shown by the numerous sea-shells, sharks' teeth, remains of pachyderms and ruminants, to belong to the newer tertiary.

LEPTINITE. Synonyme of granulite.

LETTENKOHLE. Argillaceous brown coal, or lignite beds in the Keuper of Swabia.

LIAS. The lower division of Jura formation in England.

LONDON CLAY. Bluish clays in the vicinity of London, containing many fossils; belong to the lower tertiary.

LÖSS. A yellowish friable sandy clay, common in the Rhine valley, along with some connected beds of sand and gravel.

LUDLOW ROCKS (Murchison). Highest member of the upper Silurian of England.

MACIGNO. A fine-grained compact sandstone of a dark-blue colour in the interior, and brownish grey when weathered; very common in the Apennines. It contains no fossils, except some fragments of plants, but belongs chiefly to the nummulite or lower tertiary formations. It is the common *pietra serena* or *pietra forte* of Florence.

MAGNESIAN LIMESTONE. A dolomitic limestone of the Permian formation in the north of England, corresponding to the German Zechstein.

MAJOLICA. A white compact limestone, in the Apennines and Venetian Alps. In the latter belongs to the Neocomien or lower chalk.

MELAPHYR. Dark-coloured porphyry, with a basis of augite and labradorite, or oligoclase, with crystals of augite or oligoclase. Described by Von Buch in the Fassa valley, but seems scarcely distinct from augite or greenstone porphyry.

MIASCITE. Granular mixture of felspar, mica, and nepheline, found near Miask in the Ilmen Mountains.

MICA SLATE. Laminar mixture of mica and quartz, very abundant in the crystalline group of strata.

MILLSTONE GRIT. Beds of sandstone forming the middle division of the carboniferous strata in England.

MIOCENE. Sir Charles Lyell's name for the middle tertiary strata, with from seventeen to thirty-five per cent of living species in the organic remains.

MOLASSE. A soft fine-grained grey or green sandstone, common in many parts of Switzerland. With some connected beds it forms the molasse group of the Swiss geologists, belonging to the upper tertiary. Professor Bronn and other German authors use this term as a general designation of the whole tertiary deposits.

MOUNTAIN LIMESTONE. Synonyme for the carboniferous limestone in the lower part of the coal-formation. Bergkalk of Germans.

MUSCHELKALK. Shell-limestone, the middle member of the Trias, named from the numerous remains of marine shells it contains. Hitherto scarcely known beyond Germany, the Alps, and some neighbouring parts of France, but discovered last year by De Verneuil in Spain.

NAGELFLUHE. Coarse conglomerate, containing boulders of almost all the Alpine rocks, in a calcareous basis, forming part of the upper tertiaries in Switzerland. Well seen in the Rigi.

NEOCOMIEN. Lowest member of the cretaceous series. (Atherfield Rocks, Isle of Wight).

NEW RED SANDSTONE. Synonyme for the Trias in England.

NORITE. Granular rock, composed predominantly of felspar, with very little hornblende and titaniferous iron. Occurs on Hitteröe, and near Bergen in Norway.

NORWICH CRAG. Fluvio-marine formation in the upper tertiary of England.

NUMMULITE ROCKS. Beds of limestone and sandstone, containing very many remains of nummulites, and belonging to the lower part of the tertiary strata.

ŒNINGEN SLATES. Calcareous slates, very rich in fresh-water fishes, insects, and land-plants, belonging to the upper tertiaries of Switzerland.

OLD RED SANDSTONE. Synonyme of the Devonian formation, and especially of the more arenaceous portions of it, in Hereford, Scotland, and other places.

OOLITE. Limestones composed of rounded grains or concretions, common in the Jurassic beds of England, &c. The term has been extended to the whole formation, or specially to the portion above the Lias.

OPHITE (Serpent-stone). Used as synonymous with serpentine.

OXFORDIEN. Name for the portion of the Jura formation, corresponding to the Oxford oolite in England.

OXFORD CLAY. Dark-blue clays, containing many ammonites, Gryphæa, and other fossils, with crystals of gypsum. Member of the Jurassic beds, as near Oxford, &c.

OXFORD OOLITE. Middle portion of English oolites.

PALAGONITE TUFA. Conglomerate of small rounded fragments of palagonite (mineral resembling pitchstone), in a basis of a similar nature; found in the Val di Noto in Sicily, interstratified with recent tertiary beds, and also in Iceland.

PERMIAN ROCKS (Murchison). The highest of the Palæozoic formations, containing the lower red sandstone and magnesian limestone of England—the Rothliegendes and Zechstein of Germany. (See account of formations above.)

PHONOLITE, or CLINKSTONE. Compact greenish-grey trap rock, named from its sharp ringing sound under the hammer. Common near Edinburgh, and in many parts of Germany.

PISOLITE LIMESTONE. Small concretionary limestone, lying above the chalk in many parts of France, and now usually placed in the lower tertiary group.

PITCHSTONE, (*Pechstein*, German; *Pierre de Poix*, French). Compact green, grey, or black rock, with a highly resinous lustre, common in beds or veins, in Arran, Scotland, the north of Ireland, and near Meissen in Germany.

PLÄNER. Some beds in chalk formation near Dresden were so named. Corresponding nearly to the Chalk marl and Lower Chalk of England, they consist of marls and sandy limestones.

PLASTIC CLAY, (*Plastischer Thon*, German; *Argile Plastique*, French). Beds near the bottom of the tertiary series in the London and Paris basins.

PLEISTOCENE. The most recent tertiary strata or newer Pliocene (Lyell).

PLIOCENE. Upper division of the tertiaries (Lyell), implying that in them a comparative plurality of recent species occur.

PORPHYRY. Rock characterised by distinct crystals imbedded in a compact basis, the latter generally some variety of felspar.

PORTLAND OOLITE, PORTLANDIEN. Names of the upper group of the Oolite or Jura formation in England and the Continent. Derived from the island of Portland, where it occurs.

POSIDONIA SLATE. Beds in the Lias of Swabia, containing many small Posidonomya (Bronii). The same name has been given to beds full of Posydonomya Becheri, in the upper Devonian on the Rhine.

POSIDONOMYA LIMESTONE. Black limestone, with numerous remains of Posidonomya in Devonshire, the representative of the carboniferous limestone.

PROTOGINE. A variety of granite in which the mica is almost replaced by talc; common in Mont Blanc and the valley of Chamouni in the Alps.

PURBECK BEDS. Slates, marls, and limestones, well seen in the cliffs near Purbeck, and belonging to the Wealden formation.

QUADER, or QUADER SANDSTONE. Name given to a sandstone in Saxony. (See account of, in the previous description of the cretaceous formations.)

QUARTZITE, or QUARTZ ROCK. Rock composed essentially of quartz in a compact crystalline mass, occasionally with a little felspar or scales of mica. It occurs among the crystalline strata, or as an altered rock where sandstone is in contact with igneous rocks.

QUARTZ PORPHYRY. Red felspar-porphyry, with imbedded crystals or grains of quartz.

RAUCHKALK. A cavernous drusy dolomite or magnesian limestone, in the Permian formation of Thuringia and other parts of Germany. Named from the rugged broken rocks it forms.

RED SANDSTONE, OLD. Synonyme of Devonian formation.

ROTHLIEGENDES. Red-coloured sandstones and conglomerates, which form the bed underlying (das Liegende) the Mansfield copper-slates. It contains few organic remains, especially stems of trees and ferns, and corresponds to the new red sandstone of the Permian formation.

SALIFEROUS GROUP. Sometimes used as a synonyme for the new red sandstone, as the chief deposits in which salt has been found. The Salzgebirge is, for the same reason, sometimes applied by the Germans to a portion of the Muschelkalk, and formerly by Bronn and others to the Trias. D'Orbigny uses the equivalent term Saliferien for the Marnes irisées, or red marls of the Keuper or upper Trias.

SCAGLIA. A red limestone in the Southern Alps, shown by its echinoderms and other petrifactions to belong to the chalk. The same name has been given to some grey marly beds in the lower tertiary.

SCAR LIMESTONE. Portion of the English carboniferous formation.

SCHAALSTEIN. A volcanic ash or altered clay-slate containing hornblende and grains or nodules of calc spar, which occurs in the Devonian rocks of Nassau.

SEWERKALK. Name for the equivalent of the chalk in Switzerland.

SILURIAN SYSTEM (Murchison). The lowest of the older Palæozoic rocks. (See account of formations above.)

SLATE-CLAY. Beds of clay with a schistose or laminar structure, found in the coal formation and more recent groups.

SPEETON CLAY, in Yorkshire, seems to correspond partly to the lower greensand, partly (upper beds) to the gault.

SPIRIFER SANDSTONE. Lowest fossil band in the Devonian formation on the Rhine, named from the numerous spirifers found in it.

STEPPE LIMESTONE. Recent tertiary formation found in the former basin of the Caspian Sea. (See Aralo-Caspian.)

STONESFIELD SLATES. An oolitic shelly limestone at the base of the great Oolite, remarkable for containing remains of pterodactyles and other reptiles, and especially of the Amphitherium and Phascolotherium, two genera of mammals.

SUB-APENNINE FORMATIONS. Beds of limestone containing numerous marine fossils found near the foot of the Apennines, and belonging to the newer tertiary group.

SYENITE. Granular rock of felspar and hornblende, often with a little mica and quartz; when it passes into granite. Included in the older igneous rocks.

TALC SLATE (TALCSCHISTE, TALKSCHIEFER) essentially consists of talc, but often contains some quartz or mica. It has usually a white, green or yellowish colour, is sectile, and feels greasy. It is very abundant in the Alps, and in some parts of Scotland, and contains many disseminated minerals.

TASSELLO. Sandy or marly slates and sandstones underlying the chalk near Triest, and corresponding probably to the Trias, but without fossils. The mercury mines of Idria appear to be in the formation.

TEGEL. A blue-coloured clay bed in the Vienna basin full of marine shells. The name has been extended to the whole formations of clays and sands, which are of upper tertiary age.

TERTIARY. (See notes above.)

THONSCHIEFER. (See CLAY SLATE.)

TILESTONES. Finely-laminated reddish and green sandstones and shales, forming the upper member of the Silurian rocks of England.

TOADSTONE. Local name for beds of greenstone or basalt in Derbyshire and other parts of England.

TOPAZ ROCK. Crystalline mixture of felspar, quartz, tourmaline (shorl), and topaz, which forms the Schneckenstein, a rock projecting from the mica slate near Schöneck in Saxony.

TOURTIA. Conglomerate beds found near the base of the cretaceous rocks in Belgium. They are about the level of the upper greensand of England.

TRACHYTE. A white or greyish rock composed of a basis of felspar, with small imbedded crystals of glassy felspar, scales of mica, and hornblende. Very common, in many varieties, in volcanic regions, as the Drachenfels near Bonn, in Hungary, the Lipari Islands, &c.

TRANSITION ROCKS. Werner's name for older strata, especially the Silurian.

TRAP. General term for the augite and hornblende eruptive rocks, derived from the Swedish word *trappa*, a stair, referring to their frequent appearance in terraces on the sides of hills.

TRASS. A soft earthy rock found especially in the Brohl valley on the Rhine, and used for hydraulic mortar. It appears to be the mud ejected from volcanoes, and a variety of tufa.

TRAVERTINE. Name for the calcareous deposits from springs; common in many parts of Italy.

TRIAS FORMATION. Named from its usually consisting in Germany of three members, the Keuper, Muschelkalk, and Bunter sandstein.

TUFF, or TUFA. General term for friable decomposed rocks of various kinds. Many seem the mud ashes and finer detritus thrown out during volcanic eruptions consolidated under water. Calcareous tufa is a similar earthy limestone, generally formed by deposition from springs.

UNGULITE SANDSTONE. Sandstone with bituminous shale and limestone, containing Obolus Apollinis, &c., at the base of the Silurian rocks of Esthonia.

URGEBIRGE (Primary rocks). German name for the crystalline schists and connected igneous rocks.

VERRUCANO. Conglomerates of rounded quartz pebbles in a basis of greenish-white talc, and which, in some places, are of the age of the Trias; in others, of carboniferous age with plants. The same name has been given to beds of talc-slate, mica-slate, and gneiss. It is derived from the ruin Verruca, on the southern declivity of the Monte Pisano.

VIENNA SANDSTONE. A grey sandstone with subordinate beds of sandy and marly shales, often with carbonaceous impressions and remains of Fucoids, found on the northern border of the Eastern Alps. It belongs to the upper tertiary; but this name (like Carpathian sandstone) has also been given to sandstones of older formations, cretaceous, Jura, or Trias.

VOLCANIC ROCKS. Products of the most recent igneous action on the globe.

VOLCANIC GRITS. Beds of detrital matter of igneous origin, alternating with the older rocks, were so named in the "Silurian System." The name Volcanic Ash has been given to the same rocks by Sir H. de la Beche.

VOSGES SANDSTONE. A course-grained red sandstone or conglomerate, with a few remains of plants or reptiles. It underlies the Bunter sandstone in the Vosges Mountains, and, in part at least, is Permian.

WACKE. Soft earthy rocks connected with the igneous (trap) rocks, and often apparently products of their decomposition. Common in the central district of Scotland.

WEALDEN FORMATION. Fresh-water group between the Oolite and chalk. (See Notes on Map.)

WELLENKALK. Beds of dolomite and limestone, with marly clays in the Muschelkalk of Germany.

WENLOCK LIMESTONE and SHALE (Murchison). Part of the upper Silurian rocks of England.

ZECHSTEIN. A dark-grey compact bituminous limestone in Germany, corresponding to the magnesian limestone in the centre of the Permian rocks of England.

ZIRCON-SYENITE. A syenite containing many imbedded zircons, found in Norway, near the Aggers-Elv.

PLATE 5-6

ON THE GEOLOGY AND PALÆONTOLOGY OF THE BRITISH ISLES,

BY EDWARD FORBES, F.R.S., Regius Professor of Natural History in the University of Edinburgh.

INTRODUCTORY NOTE.

The geology of the British Islands is more varied, and has been the subject of more minute investigation, than that of any other equal area on the earth's surface. It presents, in nearly continuous sequence, almost all the rocks characteristic of the successive geological epochs. Consequently it has become, in a great measure, the type of the geology of the earth; and the nomenclature of descriptive geognosy is in great part constituted out of terms locally applied in Britain.

The practical investigation and right understanding of British geology dates from the commencement of the present century, and the labours of William Smith. The exertions of a distinguished body of enthusiastic investigators have brought it to its present perfection. The construction of a complete geological map of England was first effected by Mr. Greenough, the first president of the Geological Society. Scotland was first mapped as a whole by Dr. M'Culloch, and Ireland by Mr. Griffith. The working out of the geology of the British Islands, and the investigation of its economic applications is the task of the Government Geological Survey, now in progress, guided by the comprehensive views and experienced superintendence of Sir Henry De la Beche.

A great part of the surface of the British Isles is occupied by rocks which are of sedimentary origin, and fossiliferous. Igneous rocks occur in more limited tracts, and are present in considerable variety. Of the three kingdoms, Scotland is least prolific in organic remains, and is distinguished by the preponderance of older palæozoic rocks, the exact equivalence of the several beds of which has yet to be made out, by the extent and importance of its newer palæozoic rocks, by the absence of the greater portion of the secondary and tertiary formations, and by the abundant development of igneous rocks which have in this region been investigated and defined with admirable precision, by Jameson and other eminent geognosts.

England presents but a comparatively limited display of older palæozoic strata in comparison with the area occupied by secondary formations, which form a most varied and extensive portion of her surface. The former, however, are considerably developed in the extreme north-western and south-western counties. Her great coal fields bear witness to the important part played by the newer palæozoic strata in the composition of her surface. British tertiary strata are developed chiefly in the south-east of England. Wales is the seat of a great and most important development of the older palæozoic strata. Igneous rocks occupy but a small portion of the area of England and Wales.

Ireland is essentially a palæozoic country, covered in great part by the newest tertiaries or "drift." All other formations, whether aqueous or igneous, play but an insignificant part in her constitution. The great feature presented by Ireland, is the large portion of her surface occupied by the mountain limestone.

In the following table a concise view is exhibited of the fossiliferous formations in the British Islands, and their relations to those of other countries. In the second part of the text, we have given a systematic outline of the distribution and development of the various classes of organized beings during the successive geological periods.

I.—TABLE OF THE FOSSILIFEROUS FORMATIONS IN THE BRITISH ISLANDS, SHOWING THEIR MINERAL AND PALÆONTOLOGICAL CHARACTERS, AND THEIR RELATIONS TO FOREIGN ROCKS.

POST-TERTIARY

	Principal Sub-divisions.	Mineral Character in Britain.	Chief British Localities.	Foreign Equivalents.	Palæontological Features in Britain.	General and Special References, chiefly British
	A. Marine.	*Raised Beaches*, usually shingles or shelly sands.	All round the British coasts.	Similar raised beaches occur in most maritime countries; also submerged forests and peat-bogs.	Shells, &c., such as now live in the British seas.	The references for pleistocene formations equally apply to this division. Also, especially Buckland's Reliquiæ Diluvianæ.
	Terrestrial.	Peat-bogs are the principal. Submerged forests.	Occupying large tracts in Ireland and other parts of the British isles. The submerged forests are frequent around the coast.		Remains of Vertebrata, mostly such as now live or have become extinct within our area during the historical period.	
	B. Fresh-water.	Blue or white shell marls, usually occupying basins in the pleistocene marine marls and below the peat.	In many parts of Scotland, the north of England, in the north of the Isle of Man, and frequent in Ireland.	In Northern Europe, and Boreal and Central North America; also Siberia.	Many of the bone caves have their place about this epoch. The *Megaceros Hibernicus* or Irish Elk is the characteristic fossil of these beds. Shells and vegetable remains occur therein, but all apparently of existing forms.	Owen's British Fossil Mammalia.
NEWER TERTIARIES.	Pleistocene.	1. *Glacial beds.* Sands, gravels, and clay-marls, often stratified. Boulders on their surface. 2. *Till.* Unstratified clays and gravels, with boulders. 3. *Mammaliferous or Norwich Crag.* Fossiliferous sands, shingles, and loam, partly of fresh-water origin. [The sands and clays of Bridlington are the equivalents of either 3 or 2.] 4. *Fresh-water beds.* Sands, marls, and gravels.	Generally present as drift over the greater part of Great Britain and Ireland. Fossiliferous beds occur chiefly in the North and in Ireland, Caithness and the Clyde region in Scotland, Lancashire in England, the Isle of Man, North Wales, and many parts of the north and east of Ireland. Norfolk is the region of the Mammaliferous crag, and the purely fresh-water beds (4) occur chiefly in Norfolk, Suffolk, Essex, and Kent.	TERTIARY. Pleistocene beds, presenting features very similar to those of Britain, occur in Scandinavia, Russia, Northern Germany, and North America, extending farther south in the Western than in the Eastern Continent. They appear all to have been formed in an ice-charged sea. The newer pliocene tertiaries of the Mediterranean region, of which the Sicilian beds are the type, are equivalents of our pleistocene. Similar beds with those of the northern hemisphere, and apparently of the same age, occur in South America.	The fossils found in the British marine pleistocene are chiefly remains of Mollusca. They are all either living British species now, chiefly found within the Celtic region, or such as, though still living within our area, are only abundant in the Boreal region; or such as are extinct in our seas, but still survive in the arctic regions or on the coasts of Boreal America. A few southern forms, which do not now range to our seas, accompany them. The fauna of the glacial beds, including the Mammaliferous crag, consists of above 170 species of marine animals, chiefly Mollusca. In the fresh-water beds many extinct Mammals occur.	For the tertiary formations generally, the writings of Sir Charles Lyell are the chief authorities. For special information on the British pleistocene see Mr. Smith's papers in the Wernerian Memoirs and Geological Transactions; the papers of Scoular, Trimmer, Portlock, Bryce, Oldham, Griffith, and Hamilton, in the Irish Geological Proceedings; and of Strickland, Morris, Landsborough, Austen, and Cumming, in the English; also E. Forbes, in Memoirs of the Geological Survey, where a catalogue of the marine fossils of this deposit is given. The writings of Lyell and Bayfield on the American beds, and of Murchison on the Russian and Scandinavian; and of Philippi on the Sicilian N. P. fauna, should be consulted.
	Pliocene.	*Red Crag.* Marine ferruginous, shelly sands, and marls. The fresh-water (4) pleistocene beds may, in part, belong to this epoch. *Coralline Crag.* Marine calcareous sands, limestone bands, and greenish marls.	The red and coralline crags occur chiefly in Suffolk.	The subapennine tertiaries are probably the equivalents of our red crag, and beds of the same age are found in several parts of the Mediterranean region. The brown coal beds of Germany. The Sivalik tertiaries of India.	In the red crag there have been found about 200 species of Testacea, of which 60 are now known alive in the British seas; 41 of the number are pleistocene as well, and 19 of the 41 are species common to the coasts of Europe and America. Zoophytes are few. The coralline crag abounds in shells and Zoophytes. Above 340 species of Mollusca have been collected in it, of which 73 are living British species; 23 of these are pleistocene forms. The general character of the fauna of this epoch is Lusitanian. Zoophytes abound, including many southern genera.	For the fauna of the red and coralline crags, see the papers of Searles Wood in the Annals of Natural History and in the Magazine of Natural History; Charlesworth in the Magazine of Natural History, &c.; Lyell in the same journal. Nyst's work on the Crag Fossils of Belgium contains much matter bearing on the British crags. See also the writings of Basterot, Dujardin, Lyell, &c., on the French miocene beds.
	Miocene.		Unless the leaf-beds of Mull belong to this age, and corresponding strata in Ireland, we have no miocene in Britain.	The brown-coal beds of Germany. The Sivalik Tertiaries of India. Tertiaries of Touraine and Sologne, &c.		The Duke of Argyle in the Geological Journal for 1851.
OLDER TERTIARIES.	Eocene. Upper Division.	1. *Hempstead Series.* Fresh-water and estuary marls and clays. 2. *Bembridge Series.* Limestones and marls, chiefly of fresh-water and estuary origin.	In Britain the upper eocene occurs only in the Isle of Wight.	Parts of the Bourdeaux tertiaries; certain beds in the Mediterranean islands, Spain, Portugal, and the north of Africa. Certain beds in Asia and North America. The Paris basin; the fresh-water eocene tertiaries of Central France; the Mollasse of Switzerland; certain beds in Belgium and Northern Germany; some tertiaries in Western Asia and in India. Well-marked fossiliferous beds in both North and South America. The nummulite limestone and sandstone of the Mediterranean, and of Asia and Egypt.	The general character of our eocene fauna and flora is sub-tropical. With one or two exceptions all the species are extinct, and do not range to formations either above or below. The fullest Catalogue of British eocene fossils (Mr Tennant's) gives the number as follows: Plants, 100; Zoophytes, 4; Echinoderms, 5; Foraminifera, 8; Annelida, 11; Cirrhipeda, 3; Crustacea, 4; Conchifera and Brachiopoda, 235; Gasteropoda, and Cephalopoda, 267; Fishes, 97; Reptiles, 14; Birds, 1; Mammals, 14. The number of reptiles has been greatly increased by Owen, of Echinoderms by Forbes, and of Zoophytes by Milne Edwards and Haime.	For the eocene beds of Britain, see the papers of Prestwich in the Geological Journal, and the memoirs of Sedgwick, Lyell, Webster, Bowerbank, Morris, Wright, Ibbetson, Forbes, &c. For special eocene palæontology, see the works of Owen, Agassiz, Edwards, Dixon, and Bowerbank, severally on the Mammals, Fishes and Plants; Brander, Sowerby, and Edwards, for the Invertebrata. The works on foreign eocene formations are very numerous. That of Deshayes must be consulted for fossil shells.
	Middle Division.	1. *Headon and Hordwell beds.* Fresh-water limestones, sands, and marls, with marine intercalations. 2. *Barton Clays.* Dark clays, with septaria sands and sandstones. 3. *Bracklesham Sands.*	They occur in Surrey, Middlesex, Berks, and Hants.			
	Lower Division.	1. *London Clay and Bognor beds.* 2. *Plastic Clays.* Mottled clays and sands. [Woolwich fresh-water beds come here.] 3. *Thanet Sands.*	The eocene formation is extensively developed on both sides of the Thames from near Marlborough to the sea, its eastern expanse extending from Canterbury to Saxmundham northwards. Another large expanse of it occurs in Hampshire, Sussex, and Dorset, and in the Isle of Wight. A small tract of this age is found in Devonshire.			
UPPER SECONDARY.	Cretaceous. Upper Division.	1. *Chalk with Flints.* Pure white carbonate of lime, containing horizontal bands of flint nodules. 2. *Chalk without Flints.* The same, but usually (not everywhere) free from flints. 3. *Chalk and Chloritic Marls.* Grey or yellow earthy or marly chalk, often indurated; sandstones green, from particles of silicate of iron (Dorset), or red (Norfolk and Yorkshire.) 4. *Upper Green Sand.* Siliceous or calcareous sand, with green particles and mica; often hard (firestone.) 5. *Gault.* Blue clay or marl, with nodules.	The several subdivisions of white chalk occupy a large expanse in the south-east of England, comprising considerable tracts in the counties of Norfolk, Cambridge, Herts, Buckingham, Oxford, Berks, Wilts, Hants, Dorset, Surrey, Kent, Lincoln, and Yorkshire. Outlying patches occur in Devon. In Ireland, chalk occurs in Antrim and Derry. The upper green sand forms the western boundary of the Lincoln and Yorkshire chalk; the northern and western of the chalk north of the Thames, running into Dorset. It here encircles the Weald, except on the sea-side; forms a considerable tract in the Isle of Wight; also in Devon, Dorset, and Somerset, where the Blackdown hills are famous for upper green-sand fossils. It occurs in the cretaceous districts of the north of Ireland. The gault accompanies it in the east of England, where the lower green sand also is chiefly seen, especially in Surrey, Sussex, Kent, and the Isle of Wight.	SECONDARY. Cretaceous deposits, possibly newer than ours, are those of Maestricht and part of the Denmark chalk. In France the whole of the cretaceous strata occur. In Germany the development is not so considerable. In Poland and Russia the upper beds are greatly developed. They occur also in North America. Beds of the age of the upper green sand occur in Southern India and Cape of Good Hope. The senonian, turonian, and albian stages of D'Orbigny, are equivalent to our chalk, upper green sand, and gault. The quader of the Germans is the upper green sand; and their planer our gault.	1, 2, 3. Generally speaking, the fossils of the three uppermost stages of the British chalk indicate a deep-sea condition during its formation. The corals and Brachiopods bear a striking relationship with existing deep-sea forms, and the peculiar Echinoderms (*Holaster, Galerites, Ananchytes, Cidaris, Brissus, and Goniaster,*) favour such a notion. Also the presence of numerous Foraminifera. *Inocerami* and *Spondylus spinosus* are characteristic Conchifera. *Baculites* among Cephalopods; *Marsupites* among Crinoids. Several genera of Fishes (*Beryx, Dercetis, Osmeroides, Ptychodus, Saurodon.*) The *Leiodon* and *Raphiosaurus* among Reptiles. *Turrilites* are frequent in the chalk marl, also *Scaphites æqualis.* 4. *Ammonites varians, catillus;* peculiar *Nautili.* (*Gryphæa columba* and *haliotoidea, Pecten asper, Trigonia quadrata* and *radis, Pachymya gigas, Cardium hillanum.*) Sea-urchins of the genera *Salenia* and *Catopygus*, sponges and peculiar corals. 5. *Hamites*, many species; *Ammonites*, *Bouchardianus, Nucula bivirgata* and *pectinata, Inoceramus sulcatus.*	Conybeare and Phillips' Geology of England and Wales. The writings of Mantell, D'Orbigny, Paléontologie Française, Terrain Crétacée. The works of Roemer, Goldfuss, Philippi, &c., &c. Fitton, on the Strata below the Chalk, in the 4th vol. of 2d series of Geological Transactions. De la Beche in the 2d vol. of the Geological Transactions. Dixon's Geology of Sussex. Rupert Jones, Monograph of cretaceous entomostraca. Sharpe, Davidson, and Milne Edwards on cretaceous invertebrata.
	Lower Division.	1. *Lower Green Sand.* Ferruginous sandstones and limestones (Kentish rag), with a base of clay (Atherfield clay and fullers' earth.) Bands of phosphate of lime.	Skirting the upper cretaceous districts as above enumerated. Absent from Dorsetshire westwards on the coast. The Farringdon beds are equal to the Aptien.	The neocomian of Switzerland and France (and the hilston of North Germany) is equivalent to our lower green sand. So are the greater part of the Pondicherry beds, and probably those of Bogota in South America.	The upper beds of the lower green sand are rarely fossiliferous, except at Farringdon. *Diceras Lonsdalii* is a characteristic shell. In the middle beds gigantic Scaphites, and Ammonites, and Nautili, *Gryphæa sinuata*, are frequent. Zones of *Terebratulæ* (especially *Terebratula sella*) occur at intervals. In the lower beds numerous Mollusca occur, *Ammonites Deshayesii, Gervillia aviculoides* and *linguloides; Perna Mulleti, Pleurotoma Fittoni*, and *Cardium Ibbetsoni*, are characteristic.	Fitton, ut supra; Austen, Ibbetson, and E. Forbes, in Proceedings of Geological Society, and in the Geological Journal. The writings of Dubois de Montpereux, Roemer, D'Orbigny, and Leymerie.
		* *Speeton Clay.* Dark-blue laminated clay, with nodules of clay ironstone. This is probably its true position.	At Speeton, near Scarborough, Yorkshire.	The neocomian and aptien stages of D'Orbigny, are equivalents of our lower green sand. So is the hils-conglomerate of Germany.	Peculiar Ammonites (some of them of the group Ligati,) forms of *Hamites* (sect. *Ancyloceras* and *Crioceras*) peculiar Belemnites, Conchifera approaching lower green-sand species, and *Brachiopods* resembling oolitic forms, characterize the Speeton clay, the true position of which is a matter of dispute. One fish, the *Gyrodus*, is recorded.	Phillips' Geology of Yorkshire, pt. 1.
	Wealden.	*Weald Clay and Hastings Sand.* Blue and brown stiff clay, with beds of limestone (Sussex marble), sand, and clay-ironstone; all of fresh-water origin. Variously coloured sands, sandstones and grits, the lower beds in places conglomeratic. Clays and marls alternating with sands and shells at Tunbridge Wells. Mostly of fresh-water origin, but presenting marine bands in the upper part.	The chief development of the Wealden formation is in Kent and Sussex. It is present also in the Isle of Wight and the south of Dorsetshire. The marine bands are seen in the upper part of the Hastings sand, at Punfield, near Swanage.	Wealden beds, part of the same formation with those of the south of England, occur on the opposite coast of France, but so slightly developed, as to lead to the inference that they indicate the edge of the great fresh-water Wealden basin. In the north-west of Germany, Wealden beds are extensively developed. As the Wealden, in England, is a great fresh-water formation separating the cretaceous from the true oolitic strata, it is probable that its equivalents in other parts of the world will be found in marine strata, at the base of the cretaceous or summit of the oolitic series.	The Wealden strata contain numerous remains of plants. Many insects and fresh-water crustacea occur in parts of it. Its marine fossils are partly lower green-sand species. Numerous species of *Unio, Cyclas,* and *Paludina*, are its characteristic Invertebrata. Fishes of the Placoid and Ganoid divisions, especially species of *Hybodus* and *Lepidotus*. Reptiles of many genera, among which the *Iguanodon* is conspicuous. In the limestone of the Weald clay, *Paludinæ* are the most abundant fossils. In the Hastings sand, the greater number of the terrestial Reptiles of the Wealden epoch occur.	The chief authority on the subject of the Wealden is Dr Mantell, in whose writings full details respecting this formation, as it is presented in the south-east of England, may be found. The papers of Dr Fitton, Professor Webster, Dr Buckland, and Mr Hopkins, all in the Geological Transactions. For accounts of the Wealden insects, see Brodie's work on that subject. The writings of Roemer and of Dunker should be consulted for the Wealden of Germany.
LOWER SECONDARY.	Purbecks.	*Purbecks.* Limestones, shales, sandstones, and clays, divisible into an upper, middle, and *lower series*, (the last with dirt beds), and exhibiting numerous alternations of fresh-water, estuary, and marine conditions.	Chiefly developed in the Isle of Purbeck. The lowest beds cap Portland Island. The middle and lower beds are present in Wilts.	The serpulite limestone of Germany.	The fossils of the three *divisions* of the Purbecks are distinct from each other. Insects abound in the lower division: also fossil plants. More than 80 species of invertebrata have been found. The type of the fauna is oolitic. Pulmoniferous fresh-water mollusca and gyrogonites occur in the Purbecks. Plants of the genus *Zamites*, (*Z. megaphyllus* and *microphyllus*) are common in the lower Purbecks. Fossil forests occur in this formation.	For the Geology of the Purbecks, see E. Forbes, in Jameson's Journal for 1850.
	Upper Oolites.	1. *Portland Stone.* *a.* Coarse earthy limestones thick-bedded with inter-stratified clay or cherty bands. All marine. *b.* Greenish Siliceous sand. (Portland sand.) Marine. 2. *Kimmeridge.* Blue or yellowish-grey laminated clays, with gypsum and layers of lignite, in the state of highly bituminous shale. (Kimmeridge coal.)	The upper oolites occupy small tracts in Dorsetshire, Wilts, and the Vale of Pickering, in Yorkshire.	In Normandy the lithographic limestone of Blangy, and the clays of Honfleur, are representatives of our upper oolites. Also along the coast of France. Limestones and schistose marls of this age occur in the Jura. In Germany the Solenhofen beds are about this parallel. In the south of Russia there are beds equivalents in time, and in India.	Reptiles of the genus *Chelonia* occur. The genus *Pliosaurus* is confined to the Kimmeridge. So is the *Steneosaurus*. Other large Saurians occur in the same formation. The Mollusca of the upper oolites are mostly Cephalopoda and Conchifera. Very few Articulata or Radiata occur. Several Ammonites are peculiar to these beds. (*A. rotundus, A. plicomphalus, A. omphaloides, A. Leachii, A. giganteus, A. concavus, A. biplex,* and *A. Brodiæi.*) *Ostrea deltoidea*, and some other species, *Gryphæa virgula* and *nana, Perna quadrata* are characteristic bivalves.	For the oolites generally, see Conybeare and Phillips' Geology of England and Wales, Lonsdale on the oolitic district of Bath, in the Geological Transactions, 2d series, vol. iii. Phillips' Geology of Yorkshire. The papers of De la Beche, in the Geological Transactions, and Memoirs of the Geological Survey. Buckman and Strickland's edition of Murchison's Geology of Cheltenham. Buckland's Bridgewater Treatise. Williamson, in Geological Transactions, 2d series, vols. v, and vi. Murchison on the Brora coal-field, in the 2d vol. of the Geological Transactions, 2d series. D'Orbigny, Paléontologie Française, Terrains Jurassiques, Goldfuss' Fossils of Germany, and Roemer's Works. The works of Michelin and of Goldfuss will be found useful in the determination of our oolitic corals. That of Cotteau for the echinodermata. Wright on Oolitic Echinidæ. See papers by Pratt and Morris, in the Annals of Natural History; and by Owen, in the Philosophical Transactions. Davidson's Oolitic Brachiopoda. For notices of the so-called Scotch Wealden beds, see the papers of Murchison and Sedgwick, on Skye and Brora; those of Robertson and Duff on the Weald of Elgin; see also E. Forbes on Skye, in Geological Journal for 1851.
	Middle Oolites.	1. *Coral Rag, and Calcareous Grits.* Sandy limestones filled with corals, covered by and based upon sandy beds, more or less mixed with calcareous matter, sometimes forming strata of marly rock. 2. *Oxford Clay.* Stiff blue clay, at times shaly, pyritiferous, and containing septaria, based in places on a calcareous sandstone, or sandy limestone filled with organic remains. (Kelloways rock.) 3. *Staffin Shales.* Estuary beds of calcareous shale and clays.	The coral rag is chiefly developed in Wiltshire, Berks, and Oxfordshire. Also in Yorkshire, near Pickering and Malton. The calcareous grit occurs at Brora. The Oxford clay forms a nearly continuous ribbon-like tract, winding through the midland and eastern counties of England, from Dorset to beyond the Humber, and again occurring in the oolitic tract of Yorkshire. It occurs also on the east and west coasts of Scotland. In Scotland at Brora, on the east coast, and Loch Staffin in Skye, on the west.	The Oxford clay and coral rag are present in the oolitic districts of France. The Nerinæa limestone of the Jura appears to be the equivalent of the coral rag. Equivalent beds also occur in Germany, and in the south of Russia. "Argile de dives" is the Norman representative of the Oxford clay. The "étage corallien," and "étage Oxfordien," of the calcaire Jurassique, represent, in the Nomenclature of D'Orbigny, our middle oolites. Their German appellations are Korallen-kalk, and Oxford-thon.	Numerous organic remains occur in the coral rag, especially of Zoophytes. The number of Mollusca is also very great (above 80 species are recorded.) Gasteropoda are numerous. In the calcareous grits the number of species is very much smaller. The coral rag appears to have been a true coral reef. *Ostrea gregaria* is a characteristic bivalve. The Oxford clay is rich in the remains of Cephalopoda, and is remarkable for containing in some of its beds cuttle-fishes, preserved almost entire. Not more than 40 fossil Mollusca are recorded from the British beds of this formation. Radiata are very scarce in it, but finely preserved. The Kelloways rock is rich in molluscous remains. Nearly 40 species are recorded, of which one-third are Cephalopoda. *Ammonites Brightii, cordatus, Comptoni, Sedgwickii, spinosus, Elizabethæ*, are well-marked Oxford clay Ammonites. *A. Calloviensis, Duncani* and *Gowerianus* of the Kelloways rock.	

	Principal Sub-divisions.	Mineral Character in Britain.	Chief British Localities.	Foreign Equivalents.	Palæontological Features in Britain.	General and Special References, chiefly British.
LOWER SECONDARY—*Continued.*	LOWER OOLITES.	1. *Cornbrash.* This coarse rubbly limestone, with clays and sandstones. 2. *Forest Marble.* Shelly limestone, capping sandy clays and calcareous gritstone. 3. *Bradford Clay.* Pale greyish clay, alternating with bands of tough brownish limestone. 4. *Great Oolite.* Oolitic shelly limestones of various degrees of compactness, alternating with freestones usually unfossiliferous. Locally (in Yorkshire) a hard blue limestone with oolites, sandstones, and shales, charged with fossil plants. 5. *Stonesfield Slate.* Calcareous, shelly, and gritty flagstones. 6. *Fullers' Earth.* Stiff blue clay, with bands of shelly limestone. 7. *Inferior Oolite.* Hard rubbly limestones, and soft freestones, marls, and sands, locally (in the north of England) sandstone and ironstone.	The lower oolites accompany and occupy a corresponding tract with the middle oolites, and appear in like manner in Yorkshire. The lower oolites occupy small tracts in Caithness and the Hebrides. They are finely displayed in Skye and Rasa.	The divisions of the inferior oolites are all more or less distinctly represented in Normandy. There the forest marble is known as the "Calcaire à Polypiers," on account of the number of corals contained in it; the great oolite is the "Calcaire de Caen," and the inferior oolite preserves its name. The inferior oolites are represented in the Jura by limestones alternating partly with marls and clays, and partly with shales and ferruginous bands. In Franconia the lower oolites are represented by marly beds. The relationship of the Asiatic oolitic strata with the lower and middle oolites is very obscure. In South America certain continuous strata, forming the cretaceo-oolitic series of Darwin, seem to represent the whole of the oolitic and cretaceous epochs. A. D'Orbigny's "Etage Bathonien" is equivalent to our lower oolites. In Germany, the terms walker-erde, dogger, and unter-oolith, are applied to our fullers' earth and inferior oolite. The terms Jura kalk, and group Jurassique, are very generally applied on the Continent to the oolitic formation.	Bivalves are the most abundant Mollusca in the cornbrash. *Pholadomya Murchisonii* is one of the most widely distributed. *Ammonites Herveyi* is peculiar to this bed. Also *Ammonites discus*. Though the substance of the forest marble mainly consists of organic remains, few species are described from it. The Bradford clay abounds in the encrinitic genus, *Apiocrinites*. The great oolite has furnished an immense number of organic remains. Several Reptiles (species of *Cetiosaurus*, *Pterodactylus*, *Teleosaurus*) occur in it; also Fishes. Above 60 species of conchiferous Mollusca are recorded from this formation, and about half the number of Gasteropods, but few Cephalopods. A considerable number of Brachiopoda also occur, and no fewer than nearly 40 Radiata, of various orders. In the Stonesfield slate the only oolitic Mammals have occurred, viz., the *Phascolotherium* and *Thylacotherium*. Numerous Fishes are found in this bed; and Reptiles also occur. Few fossils are found in the fullers' earth; but the inferior oolite abounds with organic remains, chiefly of Invertebrata. In it we find the greatest assemblage of oolitic Cephalopoda; and the other orders of Mollusca are equally developed. Considerably over 100 British species are recorded. The number of Radiata, however, is much less than that contained either in the coral rag or great oolite. *Ammonites Banksii, Brownii, Brockii, corrugatus falcifer, Stokesii*, and *læviusculus*, are peculiar species.	See Bean, in Magazine of Natural History, 1839. Lycett and Morris, monograph of great oolite fossils. See Buckman in Geological Proceedings, vol. iv. Owen, in the 6th vol. of the Geological Transactions, 2d series, and in his British Fossil Mammalia.
	LIAS.	1. *Alum Shale.* Loose slaty beds separated by hard shales with jet, from very fossiliferous soft shales. 2. *Marlstone.* Alternating brown clays, and marly ferruginous sands with occasional bands of limestone. Locally it consists of sands and shales. 3. *Lower Lias.* Dark laminated shales with occasional bands of limestone and concretions. 4. *White Lias.* White, sometimes micaceous sandstone or limestone (passing into the trias) by the bone bed.	The lias accompanies the great oolitic band through the centre of England, from Lyme Regis northwards, after occupying considerable tracts of country. It is continued in Yorkshire, and bounds the oolitic tract there. Smaller tracts occur in Glamorganshire, and on the opposite side of the Severn, and an outlier in Shropshire, between Whitchurch and Market Drayton. In Scotland lias occurs at Brora, and in Skye, Eigg, and Mull. In Ireland, in Antrim.	The lias occurs in France and Switzerland; in Wirtemberg, Westphalia, Northern Germany, and Bavaria. Also in India. The Germans term this formation "lias-kalk." In D'Orbigny's Nomenclature of the oolitic series, it stands as the "etage liasique." The "calcaire à gryphites" of the French, "gryphiten-kalk" of the Germans, is equal to our lower lias.	The lias is very rich in organic contents. Many species of Saurians occur in it, and abundantly. *Ichthyosauri* and *Plesiosauri* are common in it. Fishes are numerous, and very characteristic. Mollusca are generally plentiful. Above 170 species have been described from British beds. Ammonites are especially abundant, and Brachiopods are numerous. *Ammonites Bucklandi, bisulcatus, Brookii, Conybeari, Henleyi, Heterophyllus*, and *communis*, are characteristic species. Belemnites are common, and remains of cuttle-fishes. *Gryphæa incurva* is a characteristic bivalve. *Pentacrinites* are abundant, but the Radiata generally are not equal to the Mollusca in proportion of development. Star-fishes are frequent in the marlstone. Plants are frequent.	Sir Henry De la Beche on the lias of Lyme Regis, in the 2d vol. of the new series of the Geological Transactions. Conybeare and Phillips on the Geology of England and Wales. Buckland's Bridgewater Treatise.
	TRIAS, OR UPPER NEW RED SANDSTONE.	1. *Variegated Marls.* Red, blue, and green marls, and laminated clays, with rock salt and gypsum. 2. *Variegated Sandstones.* Variously coloured sandstones, with quartzose grits and conglomerates.	The triassic beds form a broken riband bordering the band of lias westwards; occupying a considerable transverse space in Derbyshire, and an isolated district with the lias in its centre in Shropshire and Cheshire. A smaller tract occurs in Cumberland.	This trias is much more developed on the Continent. There it consists of 1. "*Keuper*," or "*Marnes irisées.*" Variegated saliferous marls. 2. "*Muschelkalk.*" A fossiliferous limestone. 3. "*Bunter Sand.*" Stein, or "grès bigarré," a quartzose sandstone.	Peculiar forms of Reptiles such as the *Labyrinthodon*, and *Rhynchosaurus*, give a feature to our British trias; also the presence of certain Fishes, especially of the genus *Ceratodus*; but, on the whole, it is very free from fossils. The continental muschelkalk, however, is rich in organic remains. Among its peculiar forms are the Ceratites and the Encrinus.	Sir R. Murchison and Mr. Strickland on the New Red Sandstone, in the 5th vol. of Geological Transactions, 2d series. Professor Sedgwick, in the 4th vol. of the same. The Reptiles of our trias have been described by Owen in the Geological Transactions, and those of the Cambridge Philosophical Society.
				PALÆOZOIC FORMATIONS.		
UPPER PALÆOZOIC.	PERMIAN. A. Magnesian Limestone series.	Grey thin-bedded limestone, red marl, and gypsum. Earthy, occasionally hard and crystalline magnesian limestone, the lower part arenaceous and red. Concretionary, and oolitic in places.	Extending through Nottinghamshire, Yorkshire, and Durham, as far as the mouth of the Tyne. Occupying a considerable area in Durham. Also in Cumberland, and Westmorland.	The term "Permian" has been given by Sir Roderick Murchison, to this, the highest section of the palæozoic series, on account of its great development in the district of Perm in Russia.	In Britain remains of Fish are found in the magnesian limestone. Reptiles (the *Thecodontosaurus*, and the *Palæosaurus*) have been found in the magnesian conglomerate of Bristol. Invertebrata, many of their forms distinctly linking the Permian beds with the other palæozoic formations, occur in the magnesian limestone of the north of England. Plants also occur allied to those of the coal measures. Out of 277 species of Permian fossils, 143 occur in the British islands, (19 vertebrata, 117 invertebrata, and 7 Plants,) and of these 109 are peculiar. (King.) Reptiles occur in the Permian of Germany. Footsteps of birds on sandstone, probably of the same age, in the United States.	Sedgwick Geological Transactions, 2d series, vol. iii. (for the Permian of the north of England). Murchison, Geology of Russia. Papers in the Geological Proceedings, by various authors. King, monograph of the Permian fossils of England. Howse, in Transactions of the Tyneside Naturalist's Club. The writings of De Verneuil, Keyserling, Naumann, &c.
	Dolomitic Conglomerate.	Fragments of mountain limestone, embedded in a red or yellow magnesian paste.	Near Bristol, and around the Mendips; occupying a considerable area in Glamorganshire.[1]	In Germany the Permian series consists as follows:— A. Mag. Limestone. Zechstein, Letten. Stinkstein. Rauwacke. Shells, Argil. Schist. Kupferschiefer. Arenaceous Schist.		
	B. Lower New Red Sandstone series.	Marls with thin bands of compact and shelly limestone. Lower new red sandstone (Rothe-todte-liegende), quartzy grits or fine-grained sandstones, coloured by oxide of iron. The fine sands and marls mostly uppermost. Concretionary limestones in the lower beds in places.	Bordering the coal districts in Cumberland, Westmoreland, Lancashire, Durham, Yorkshire, Cheshire, Shropshire, Staffordshire, Worcestershire, Nottinghamshire, and Warwickshire.	Rothe-todte-liegende. In France it is present in the north, and the formation is known as the "terrain pénéen," "terrain dolomitique," and "terrain psammerythrique." It is present in Styria, and on the northern bounds of Illyria. Permian rocks occur also in North America.		
	CARBONIFEROUS. A. Coal-Measures.	Seams of coal alternating with shales and sandstones, and in certain districts ironstones. In Staffordshire this part of the series is capped by greenish grits of considerable thickness (considered a volcanic grit by Murchison). Local bands of pale fresh-water limestone (Ardwick limestone), in parts of Shropshire, Lancashire, and Warwickshire. The coal in England and Scotland is usually bituminous. In Ireland and South Wales anthracitic coals are extensively developed. The Burdiehouse fresh-water limestone of Scotland takes its place between the coal measures and the millstone-grit.	Coal fields of England and Wales. 1. Durham and Newcastle. 2. Cumberland. 3. Yorkshire and Derbyshire. 4. Lancashire and Cheshire. 5. North Staffordshire. 6. Flintshire and Shropshire. 7. South Staffordshire. 8. Leicestershire. 9. Gloucestershire and Somersetshire. 10. Forest of Dean. 11. Glamorganshire and Monmouthshire. Great coal field of Scotland, in the counties of Ayrshire, Renfrewshire, Lanarkshire, Stirlingshire, Linlithgowshire, Haddingtonshire, Edinburghshire, Fifeshire, & neighbouring small counties. The Irish coal fields are very small. They occur chiefly in Antrim, Tyrone, Kilkenny, and Tipperary.	The carboniferous system is present in several parts of Europe, especially in certain parts of Germany (Westphalia), Belgium, Russia, and Central France. The "kiesel-schiefer," (black impure limestones, and siliceous schists) of Germany, are equivalents of the mountain limestone. Belgian beds appear to be of the same age. Great coal fields exist in Russia, the lower parts of the series consisting of alternating sandstones and shales, the upper of limestones. Extensive coal fields exist in North America. Coal fields are also known to exist in India, China, and Australia.	The coal measures are rich in the remains of monocotyledonous plants and ferns, forming a peculiar and characteristic flora. (*See tables on Map.*) Animal remains are comparatively scarce. The Burdiehouse and Gilmerton beds have furnished some remarkable Fishes. *Megalichthys* and *Holoptychius* are characteristic forms. In the Ardwick fresh-water limestone, some remarkable remains of fresh-water animals occur. Remarkable Crustacea are found in some beds of this series, and remains of insects and Arachnida. Reptiles have recently been discovered in the coal measures of Germany.	See the various memoirs and treatises on the British coal fields, and numerous papers in the Geological Society's Transactions, and proceedings in the Manchester Geological Transactions. The writings of Bald, Milne and others on the Scottish coal fields. De la Beche in the 1st vol. of the Memoirs of the Geological Survey. Lindley and Hutton's Fossil Flora of Great Britain. Jukes on Staffordshire.
	B. Millstone-grit, and Limestone Shales.	Coarse quartzose sandstones, and pebbly grits alternating in localities with thin beds of bad coal. The lower part in places consists of laminated, and sometimes bituminous shales with thin bands of ironstone and limestone. Alternating beds of limestone, sandstone, and shale, take the place of the millstone-grit in part of Scotland.	Extensively expanded in the coal districts of the north of England. Present in the Welsh and Irish fields. Absent from the south Staffordshire coal field, where the coal measures rest directly on Silurian limestones.	Foreign synonyms of carboniferous formations. Steinkohlengebirge. Terrain carbonifère. Terrain houiller. Terrain anthraxifère.		
	C. Mountain Limestone.	Beds of limestone often very fossiliferous, locally alternating with beds of grit, shales, and coal seams. In Ireland, consisting of two great bands of limestone with (in certain districts) a considerable thickness of shales and argillaceous limestones and sandstones between, forming the *calp*. The Irish mountain limestones pass into the Devonian series by the carboniferous slates and yellow sandstones of Griffith.	Extensively developed in the north of England and Derbyshire. Present in Flintshire, Denbighshire, Shropshire, South Wales, Gloucestershire, and Somersetshire. Occupying a great part of the area of Ireland. In Scotland generally forming the lower beds of the Carboniferous series.	Berg kalk. Calcaire de montagne.	The mountain limestone abounds in fossils, especially remains of Mollusca and Radiata. These have a close relationship with the Devonian species. The genus *Goniatites* is greatly developed in it, also peculiar forms of *Nautilus*; and among Brachiopoda, *Productus Terebratula*, and *Spirifer*. The section *Martinia* of the latter genus is very characteristic. Numerous Crinoids of many genera occur, and corals in great plenty. The genera *Palechinus* and *Pentremites* among Echinodermata, and *Phillipsia* among Trilobites, are characteristic. Fishes of many genera occur. *Hybodi, Petalodi, Psammodi, Cladodi*, and *Pœcilodi*, are frequent in certain localities. Tracks of unknown marine invertebrata are abundant in the sandstones, alternating with limestones, at Alston Moor.	Phillips' Geology of Yorkshire. Griffith and M'Coy. Synopsis of the Carboniferous Fossils of Ireland. De Koninck's Carboniferous Fossils of Belgium. Murchison and De Verneuil on the Geology of Russia. Ure's History of Kilbride.
	D. Calciferous Sandstones, and Carboniferous Slates.	In Scotland the coal-measures of Berwickshire are equivalents of mountain limestone. Beds of black limestone succeeded by siliceous flagstones, sandstones, and shales (*culm*), constituting the culmiferous measures of Devonshire.	The calciferous sandstones are largely developed in Scotland, and include the building stones of Craigleith and Granton.			
	DEVONIAN. Old Red Sandstone.	1. *Old Red Conglomerate.* Quartzose conglomerates, and hard fine-grained sandstones, alternating with marls in places. In Scotland the upper beds consist of quartzy yellow sandstones, impure limestones, and gritty red sandstones. 2. *Cornstone and Marls.* Argillaceous marly beds, alternating with sandstones and impure limestones, called cornstones, often including micaceous flaggy beds. In Scotland the middle beds consist of greyish fissile sandstones, grey flags, and occasional marls. 3. *Tilestone.* Micaceous and quartzy greenish sandstones, with reddish shales. In Scotland represented by a series of beds, consisting of red sandstones, bituminous schists, and coarse grits alternating with marls, with a base of a thick conglomerate; extensively developed.	The old red forms a great tract in the borders of South Wales, and in the neighbouring English counties, having Hereford for its centre. Outlying patches occur in Radnorshire. A broad band of old red crosses Scotland from the Firth of Forth to the Firth of Tay, and northwards to Stonehaven. Considerable tracts occur in Berwickshire, Haddingtonshire, Ayrshire, and Lanarkshire. On the north-east it forms a large part of the country around the Murray and Dornoch Firths, the greater part of Caithness, the Orkneys, and part of Zetland. On the west coast it forms tracts in Sutherland, Ross, Skye, and Rum. In Ireland a large tract of old red occurs in Tyrone and Fermanagh. Others in Mayo, Sligo, Clare, Tipperary, and Limerick. Beds of this age occupy large portions of Kilkenny and Waterford, and are immensely developed in Cork and Kerry.	Devonian strata are extensively developed on the Continent. To these belong "the old rocks on the right bank of the Rhine, between Westphalia and the chain of the Taurus, in the Harz district, and in the northern flank of the Fichtelgebirge." They include a series of shales, slates, and limestones, containing many fossils identical with those of South Devon. In Belgium and the Eifel, and elsewhere on both banks of the Rhine, Devonian strata are largely developed. In Russia the old red sandstone occupies a large expanse. In the United States, and in Canada, are beds of the same age. The palæozoic limestones of Australia and Van Diemen's Land appear to be equivalents of the Devonian. (See Strzelecki on Australia.) Devonians occur in the Caucasus, in China, and in Spitzbergen and Nova Zembla.	Remains of Fishes are most characteristic of the old red sandstone at home (*see tables on Map*) and abroad; but large tracts are entirely devoid of organic remains. The presence of *Holoptychius nobilissimus* in the upper beds, of *Cephalaspis* and *Onchus* in the middle, and of Dipterus, Pterichthys *Coccosteus*, &c., in the lower, afford good palæontological characters for each. Remains of Fishes are much more abundant in the Scottish than in the English beds. Invertebrate remains are very rare in the former, and only frequent in the lower beds of the latter. Agassiz regards the Devonian Fishes as representing the embryonic stage of Fishes. They are all either Ganoids or Placoids. The Devonian strata of Devonshire contain abundant fossils, more especially Mollusca, Crustacea, and Zoophytes. (See works of Phillips, and of D'Archiac, and De Verneuil.) The latter are very numerous. So are the Brachiopoda; and among them we find certain forms, such as the genus *Stringocephalus*, especially characteristic of this formation. The general assemblage of Devonian fossils decidedly ally the Silurian with the carboniferous fauna. Several species are common to the Devonian, and the beds above and below. Fishes are comparatively rare.	On the old red sandstone of England consult Murchison's Silurian System. On that of Scotland, see Hugh Miller's Old Red Sandstone, and the writings of Lyell, Malcolmson, and Prestwich, &c. See Agassiz, Monograph of the Fishes of the Old Red Sandstone. On the Devonian beds of England consult Murchison and Sedgwick's Memoir on Devonshire, in the 5th vol. of the 2d series of the Geological Transactions; the Geological Report on Devon, &c. of De la Beche; the Palæozoic Fossils of Devon, by Phillips; the papers of Austen and Lonsdale. The Memoir of Murchison and Sedgwick on the Rhenish formations; the work of Roemer, and the "Geology of Russia," for Continental information. The papers of Von Buch, De Verneuil, &c. See also Murchison's Siluria.
	Devonian Beds.	A. Coarse red flagstones and slates. B. Calcareous slate, limestones, arenaceous beds and conglomerates.	In the west of Somerset, the south of Devon, and a great part of Cornwall.	*Foreign Synonyms.*—Vieux grès rouge; jüngere grauwackegebirge; terrain paleo-psammerythrique.		
LOWER PALÆOZOIC.	SILURIAN.	[DIVISIONS AS FOUNDED BY MURCHISON.]				
	A. Upper Silurian. *a. Ludlow Group.*	*a. Upper Ludlow.* Slightly micaceous, grey thin-bedded sandstones. *b. Aymestry Limestone.* Grey and blue argillaceous limestone. *c. Lower Ludlow.* Sandy, liver, and dark-coloured shales and flags, with concretions of earthy limestone.	The Upper Silurians are chiefly developed on the borders of Wales, in the counties of Denbigh, Salop, Montgomery, Radnor, Brecknock, and Caermarthen. Patches form the Malverns, and other tracts in Gloucestershire, Hereford, and Monmouthshire; also at Dudley and Walsall in Staffordshire. They are extensively displayed in the lake district. Some of the Silurian tracts of the west of Ireland, and part of the chain of Kildare, are clearly upper. In Scotland they appear to be very slightly developed.	Silurian strata are extensively developed in the north of Europe (Norway, Sweden, Russia), and Westphalia, Bohemia, Brittany. They have been discovered by Strickland near Constantinople, and by Abich on the flanks of Mount Ararat, and by Strachey in the Himalaya. In North America they are very extensively developed, and have been examined by American geologists in great detail. All these Silurian districts may be regarded as linked palæontologically by numerous species in common with the Silurian formations of our own country. They appear to exist in South Africa, China, Tierra del Fuego, and the Falkland Isles; but it is not improbable that the palæozoic deposits of the southern hemisphere do not correspond with those of the northern as to duration in time.	Great interest attaches to the palæontology of the Silurians, on account of their presenting us with the most ancient forms of organized beings. Representatives of all the great types of life are present in them, but not of all the sub-divisions. Of the vertebrata we have only traces of Reptiles (?) and Fishes. All the sections of the Mollusca are present, the Cephalopoda and Brachiopoda prevailing; Trilobites are the principal and most characteristic of Crustacea in this formation. Zoophytes are abundant. The Silurians appear to have been deep-sea formations. The several sub-divisions are characterized palæontologically, as follows:— *a.* Homalonotus Knightii and Ludensis, Serpulites longissimus, Lingula minima, Orbicula rugata, Nucula ovalis, and Cypricardia cymbæformis, and other species. Chonetes sarcinulata, and Terebratula navicula, are abundant and characteristic forms. *b.* Atrypa affinis, Pentamerus Knightii, Terebratula Wilsoni, and Lingula Lewisii. *c.* Cardiola, Lingula lata, Pleurotomaria Lloydii, Orthoceratites, Crinoids, Phragmoceras, Graptolithus Ludensis, Tentaculites tenuis. *d.* Great abundance of corals and Trilobites (Calymene and Bumastus especially characteristic); frequency of Leptæna euglypha and depressa. Numerous other Brachiopods; Crinoids, Euomphali, Pseudocrinites. *e.* Terebratula Stricklandi, Asaphus longi-caudatus, Orthis antiquata, Spirifer sinuata, Leptæna transversalis, Sycocystites. *f.* Trinuclei, Leptæna sericea, Orthis alternata, testudinaria, &c. (Orthis elegantula abundant), Pentamerus lævis, Tentaculites annulatus. *g.* Ogygia Buchii, Ampyx nudus, Lingula attenuata, Orthis Actoniæ, Graptolites foliaceus and Murchisonii. Many of the above fossils range through several or all the beds, and connect the parts of the system.	Sir R. Murchison on the Silurian System. The Memoirs by Sir Henry De la Beche and Professor Ramsay, in the Memoirs of the Geological Survey, vol. i. Griffith and M'Coy, Synopsis of the Silurian Fossils of Ireland. Portlock's Report on the Geology of Londonderry, &c. The papers of Sedgwick, Horner, Lyell, Sharpe, Bowman, Cumming, Salter, Yates, &c., in the publications of the Geological Society. Davidson in the London Geological Journal. Burmeister's Trilobites. For foreign information see "the Geology of Russia," the writings of Swedish naturalists, the works of Von Buch, Lyell, De Verneuil Eichwald, Pander, Barrande, the American Geological Reports, &c., &c. Nicol, Harkness, Moore, and others on the Scottish Silurians.
	b. Wenlock Group.	*d. Wenlock Limestone.* Highly concretionary grey and blue sub-crystalline limestone. *e. Wenlock Shale.* Argillaceous shale, liver and dark-grey, rarely micaceous, with nodules of earthy limestone.				
	B. Middle Silurian. (or Upper Caradoc.)	*f. Caradoc.* * Thin-bedded, impure, shelly limestone, and finely laminated slightly micaceous greenish sandstone. ** Thick-bedded red, purple, green, and white freestones, conglomeratic quartzose grits, and sandy and gritty limestone.				
	C. Lower Silurian. (And Cambrians of Sedgwick.)	*g. Llandeilo Flags.* Dark-coloured flags, mostly calcareous, with some sandstone and schist. (The Plinlymmon and Bala Rocks fall here.)	Lower Silurians, and Cambrian rocks, are most extensively developed in Wales, and occur in small patches in Cornwall, and in some of the central English counties, either with or without upper beds. They are extensively developed in the lake district and in the south of Scotland; also in and around the county of Louth in Ireland, and in Wicklow, Wexford, and Waterford. Other tracts occur in the centre and west of Ireland. The Isle of Man is chiefly composed of Cambrian rocks.			
	D. Cambrian.	* *Lingula flags*, or Primordial zone of Barrande. ** *Cambrian rocks* of Longmynd and their equivalents.				

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[1] See published Maps of the Geological Survey of Great Britain

II. DISTRIBUTION OF ORGANIZED BEINGS IN TIME, ESPECIALLY OF THOSE PRESERVED IN BRITISH STRATA.

VERTEBRATA.

MAMMALIA.

The oldest remains of Mammals date as far back as the oolitic period. They are Marsupial quadrupeds, *Amphitherium Broderipii*, *Amphitherium Prevostii*, and *Phascolotherium Bucklandi*. They occur in the Stonesfield slate, and as yet but few relics of these interesting extinct creatures have been found. An insectivorous mammal has lately (1854) been found in the Purbecks.

The next evidence of the presence of Mammals within our area is furnished by the London clay, chiefly by the fresh-water or fluvio-marine beds of the Isle of Wight. The following British Eocene Mammalia have been recorded, all the species and most of the genera being extinct :—

Macacus eocenus, Owen.
Anoplotherium commune, Cuvier.
——— *secundiarum*, Cuvier.
Chæropotamus Cuvieri, Owen.
Dichobune cervinum, Owen.
Palæotherium crassum, Cuvier.
——— *curtum*, Cuvier.
——— *medium*, Cuvier.

Palæotherium minus, Cuvier.
Hyracotherium cuniculus, Owen.
——— *leporinum*, Owen.
Microchærus erinaceus, Charlsw.
Spalacodon ———? Charlsw.
Lophiodon minimus, Owen.
Didelphis Colchesteri, Owen.
Coryphodon eocenus, Owen.

In the upper tertiaries it is difficult to draw definite lines between such of our Mammals as belonged to the pliocene and perhaps miocene epochs, and such as lived during the pleistocene, and the commencement of the present. Many of them appear to have lived through all; others to have inhabited our area during the pliocene, deserted it during the pleistocene, and to have again returned; some to remain even until now, others, from causes not yet very clearly made out, to have become extinct before man's sway in these regions. Peat-bogs, pits of fresh-water marl, and above all, ancient caves, have supplied most of the remains of our later tertiary and post-tertiary Mammals.

The principal forms, either entirely extinct, or extinct within the British area, found under such circumstances, are the following :—

QUADRUMANA : *Macacus pliocenus*.

CARNIVORA : *Hyæna spelæa*, *Felis spelæa*, *Felis pardioides* (in the mammaliferous crag). *Machairodus latidens*, *Ursus arctos* (extinct so far as Britain is concerned), *Ursus priscus*, *Ursus spelæus*, *Canis lupus* (extinguished in Britain within record of history).

RODENTIA : Species of *Arvicola*, *Castor Europæus* (extinguished in Britain within record of history), *Trogontherium Cuvieri*.

PACHYDERMATA : Species of *Mastodon (angustidens* in mammaliferous crag), *Elephas primigenius*, *Hippopotamus major*, *Rhinoceros leptorhinus* and *tichorinus*; *Sus scrofa* (no longer wild in Britain); two species of *Equus*.

RUMINANTIA : *Bison*, two species, *Bison minor*, and *Bison priscus* ; *Bos primigenius* and *Bos latifrons* ; *Cervus euryceros*, *Tarandus* and *Megaceros* ; *Strongyloceros spelæus*.

CETACEA : Several apparently extinct species of *Balaena*.[1]

In foreign countries no fossil Mammals have been discovered in formations older than the tertiary epoch. In the Paris basin numerous species have been found of the eocene age. During the later tertiary epoch, and previous to its pleistocene stage, numerous Mammals appear to have existed in all parts of the world. Auvergne, Aix, and Oeningen, are the chief European localities for their remains. Several of the more characteristic eocene genera, especially of Pachyderms, no longer appear in beds of this period. Ruminants become very numerous, and Carnivora increase. Among European animals of this time were some very extraordinary forms, especially the *Macrotherium* and the *Dinotherium*. The strata of the Sivalic Hills in India, so rich in remains of Vertebrata, many of them very extraordinary forms, a knowledge of which we mainly owe to the enterprise and research of Dr. Falconer and Major Cautley, were most probably formations of the later tertiary epoch, and perhaps continuous even to the post-tertiary time. The great number of species of Pachydermata, especially of elephant, and the presence of extinct genera of Mammals, such as the *Sivatherium*, give a peculiar feature to the ancient Sivalic fauna. The presence of numerous extinct forms of Mammals, both genera and species, along with gigantic extinct Reptiles, and others undoubtedly identical with existing Indian species in their Indian formations, is certainly one of the most interesting facts ever made known through palæontological research.

In caves and drift, not a few pleistocene and post-pleistocene Mammals have been found on the continent of Europe, most of them identical with such as are found under similar circumstances in Britain. The Mammoth of Siberia is an instance of a pleistocene Mammal being preserved entire in a frozen soil. Other remains of the same age occur in the north of Asia. In the south of Africa, it would appear that Mammals of pleistocene and post-pleistocene age exist. In North America they are almost identical with those of Europe ; but in South America an immense and peculiar assemblage of Mammalia occurs, especially in bone caves in Brazil, with the contents of which Dr. Lund has made us acquainted, and in certain deposits of the Pampas, and extreme south, explored by Mr. Darwin. The presence of gigantic Edentata, such as the Megatherium, Megalonyx, Mylodon, and Glyptodon, is the most remarkable feature of the South American pleistocene fauna, which seems curiously to have represented, though on a grander scale, the actual zoological *facies* of the province.

The following table will serve to exhibit the extent of development of generic forms of Mammalia, during the several geological epochs.

TABLE OF THE PRINCIPAL RECORDED GENERA OF FOSSIL MAMMALIA.

Palæozoic Permian and Trias.	Oolitic Formations.	Cretaceous.	Eocene Tertiaries.	Miocene and Pliocene Tertiaries.	Pleistocene and Post-pleistocene Strata.	
					Extinct forms of	
0?	Thylacotherium. Phascolotherium. Spalacotherium.	0?	Macacus. Vespertilio. Milans? Taxotherium. Palæocyon. Pterodon. Canis. Viverra. Microchœrus. Sciurus. Myoxus. Lagostomus. Megamys. Chæropotamus. Hyracotherium. Lophiodon. Palæotherium. Anoplotherium. Xiphodon. Dichobune. Adapis. Delphinus. Didelphis. Coryphodon. Zeuglodon.	Mesopithecus. Macacus. Simia? Semnopithecus. Vespertilio. Oxygomphius. Dimylus. Erinaceus. Sorex. Mygale. Talpa. Ursus. Amphicyon. Amphiarctos. Canis. Amanthodon. Hyænodon. Agnotherium. Viverra. Mustela. Gulo. Palæomephitis. Stephanodon. Lutra. Hyæna. Felis. Phoca. Arctomys. Myoxus. Archæomys. Echimys. Cricetus. Arvicola. Castor. Palæomys. Titanomys. Chalicomys. Mus. Chelodus. Hystrix. Theridomys. Macrotherium. Elephas. Mastodon. Hippopotamus. Chæropotamus. Hyotherium. Anthracotherium. Rhinoceros. Tapirus. Lophiodon. Palæotherium. Anoplotherium. Chærotherium. Chalicotherium. Oplotherium. Cainotherium. Microtherium. Listriodon. Hippotherium. Equus. Camelus. Dromotherium. Camelopardalis. Dorcatherium. Cervus. Moschus. Palæomeryx. Antilope. Capra. Bos. Sivatherium. Antelope. Dinotherium. Metaxytherium. Delphinus. Physeter. Balæna. Halianassa. Squalodon. Balænodon.	Rhinolophus. Ursus. Hyæna. Viverra. Castor. Lepus. Lagomys. Elephas. Hippopotamus. Sus. Rhinoceros. Elasmotherium. Merycotherium. Cervus. Antilope. Ovis. Bos. Ziphius. Balæna. Balænoptera. Cetotherium. Dasyurus. Thylacinus. Macropus. Hypsiprymnus. Phascolomys. [The last five genera in Australia, besides numerous still existing species belonging to various genera.] —— Add to the above the following genera, of which species are found in deposits probably of the same age in South America: Cebus. Callithrix. Protopithecus. Iacchus. Diœpes. Phyllostoma. Vespertilio. Ursus. Nasua. Canis. Speothos. Gulo. Mephitis. Hyæna. Icticyon. Felis. Cynailurus. Lagostomus. Aulacodon. Nelomys. Echimys. Lonchophorus. Ctenomys. Hesperomys. Myopotamus. Synetheres.	Lepus. Anœma. Kerodon. Chloromys. Cœlogenys. Hydrochœrus. Megatherium. Megalonyx. Mylodon. Scelidotherium. Cœlodon. Sphærodon. Glyptodon. Hoplophorus. Pachytherium. Chlamydotherium. Dasypus. Euryodon. Heterodon. Orycteropus. Glossotherium. Elephas. Mastodon. Sus. Dicotyles. Tapirus. Macrauchenia. Toxodon. Equus. Auchenia. Cervus. Antilope. Leptotherium. Bos. Zeuglodon. Didelphis.

AVES.

The first traces of Birds are to be found in certain impressions on sandstones, probably of Permian age, in the state of Massachusetts. They are supposed to be foot-prints, and have been named Ornithichnites. No such markings have been as yet observed in Britain. Except some traces in the oolites, our earliest supposed Bird is the *Cimoliornis Diomedeus* of Owen, from the chalk of Maidstone. Doubts have recently been entertained respecting the true nature of this fossil, and Mr Bowerbank has maintained that it is a *Pterodactyle*. On the Continent, remains of Birds of two epochs have been found in the peculiar eocene slates of Glaris in Switzerland. The *Lithornis vulturinus* is a British eocene fossil bird. Several eocene remains of this class have been found on the Continent. In the newer tertiaries also both at home and abroad remains of Birds occur ; but we have no reason to believe that our knowledge of this part of the Vertebrate fauna of any former period is at present very unsatisfactory and incomplete. In all, between forty and fifty species of fossil birds have been detected.

The most remarkable extinct Birds which have yet been found are those of the gigantic *Dinornis* and its congeners, which appear to have existed in post-pleistocene times, probably at an epoch corresponding with that of the Irish elk in our own country.

REPTILES.

The first supposed indication of a Vertebrate animal is the trail discovered by Mr Logan in the Potsdam Sandstone, the lowest Silurian fossiliferous stratum in Canada. This is now regarded, however, as made by a Crustacean. The *Archegosaurus* is a carboniferous epoch reptile, made known in Germany by Goldfuss, and the *Apateon* discovered by Von Meyer. Carboniferous reptiles have been found in Britain and America.

Reptiles are found in the magnesian conglomerate of Bristol. The *Palæosaurus cylindrodon*, and *Palæosaurus platyodon*, and the *Thecodontosaurus antiquus*, all made known by Dr Riley and Mr Stutchbury, are the species therein found. They are Lizards.

In the upper new red sandstone, or trias, we find the number of remains of Reptiles increase; members of several families, viz., Chelonians, Batrachians, Lacertilians, and Enaliosaurians. The presence of members of the second, or Frog tribe, is a remarkable feature of the trias. Six species of the extraordinary Batrachian genus, *Labyrinthodon*, have been described by Owen; and the *Cheirotherium Hercules* of Egerton would seem to be the foot-prints of similar animals. *Cladyodon* and *Rhyncosaurus* are other remarkable reptilian genera of this formation; and in Scotland and Cheshire foot-prints of *Testudo* and of *Emys* have been observed on the surface of new red sandstone beds.

The British lias is a store-house of fossil reptiles. In it we find the greater number of those extraordinary creatures the *Ichthyosaurus* and *Plesiosaurus*. No fewer than nine species of the former genus, and eleven of the latter, have been collected in beds belonging to this part of the oolitic formations. Lyme Regis, Whitby, and Aust Cliff, are among the localities most prolific in their remains. With them, at the first-named place, occurs the *Pterodactylus macronyx* of Buckland. *Teleosaurus* and *Rysosteus* are also British liassic Reptiles. Other oolitic Reptiles are the *Pliosaurus* (Owen), of which two species occur in the Kimmeridge clay; the *Steneosaurus* from the same beds, the *Streptospondylus Cuvieri*, and the *Cetiosaurus (longus* and *medius)*, species of *Ichthyosaurus* and *Plesiosaurus*, occur also in the Kimmeridge; and *Pterodactylus Bucklandi* is from the great oolite, as also *Teleosaurus Cadomensis*. (*Teleosaurus asthenodeirus* is a Kimmeridge species.) The *Megalosaurus Bucklandi* is found in the great oolite at Stonesfield; and remains of *Emys*, *Chelonia*, and *Lacerta*, are recorded from oolitic beds. *Macrorhyncus* occurs in the Purbecks at Swanage.

The fresh-water beds of the Wealden have furnished many remarkable Reptiles; for a knowledge of which we are indebted to the indefatigable researches of Dr. Mantell. Two species of *Chelonia*, a *Platemys* and a *Tretosternon*, species of *Megalosaurus* (the same with that in the great oolite), *Suchosaurus*, *Hylæosaurus*, *Goniopholis*, *Streptospondylus*, *Poikilopleuron*, *Cetiosaurus* (two species), and the wonderful *Iguanodon Mantelli*, constitute our British Wealden reptilian fauna.

In British cretaceous beds a number of fossil Reptiles have been found. The *Pterodactylus giganteus* of Bowerbank, the *Iguanodon Mantelli*, the *Plesiosaurus pachyomus*, and the *Mosasaurus Hoffmanni*, may be regarded as most interesting. The other genera are *Raphiosaurus* (one species), *Polyptychodon*, *Leiodon* (one species), and *Chelonia* (two species).

The Reptiles of our eocene strata are chiefly Turtles. Eleven species of *Chelone*, six of *Emys*, and two of *Platemys*, and eight of *Trionyx* have been found, chiefly at Sheppy and Hordwell. In the first locality, the remains of a snake, the *Palæophis toliapicus* of Owen, are not uncommon. Crocodiles of two species have been found at Sheppy ; *Crocodilus Hastingsiæ* has been discovered by the Marchioness of Hastings at Hordwell ; and an alligator has been found by Mr Searles Wood in the same locality. The *Gavialis Dicksoni* is from Bracklesham. Thus it would appear that our eocene reptilian fauna was of a tropical character, even as the Mammalian and invertebrate faunas of that epoch, and as the plants appear to have been.[2]

No remains of Reptiles have as yet been found in our upper tertiaries. But in equivalent beds abroad numerous forms have occurred. One of these is the celebrated fossil salamander (*Andrias Scheuzeri*,) once supposed to be human. The extraordinary gigantic tortoise of India, *Collossochelys* of Falconer and Cautley, also takes place there.

In the accompanying table a full list is given of the genera of Fossil Reptiles.

TABLE OF PRINCIPAL RECORDED GENERA OF FOSSIL BIRDS AND REPTILES.

Lower Palæozoic.	Devonian and Carboniferous.	Permian.	Trias.	Oolitic Formations, and Wealden.	Cretaceous Formations.	Eocene Tertiaries.	Miocene and Pliocene Tertiaries.	Pleistocene.
REPTILES.								
	Archegosaurus. Apateon. —— All extinct species.	Protorosaurus. Thecodontosaurus. Palæosaurus. Rhopalodon. —— All extinct species.	Testudo. Chelonia. Emys. Phytosaurus. Ichthyosaurus. Plesiosaurus. Nothosaurus. Dracosaurus. Cladyodon. Rhyncosaurus. Mastodonsaurus. Belodon. Zanclodon. Labyrinthodon. [Cheirotherium] Dicynodon. —— All extinct species.	Testudo. Emys. Trionyx. Chelonia. Teleosaurus. Steneosaurus. Mystriosaurus. Ichthyosaurus. Plesiosaurus. Cetiosaurus. Megalosaurus. Pliosaurus. Gnathosaurus. Rhacheosaurus. Pleurosaurus. Streptospondylus. Colliosaurus. Geosaurus. Suchosaurus. Hylæosaurus. Iguanodon. Goniopholis. Macrorhyncus. Pterodactylus. &c. —— All extinct species.	Chelonia. Plesiosaurus. Mosasaurus. Leiodon. Raphiosaurus. Iguanodon. Polyptychodon. Pterodactylus. —— All extinct species.	Testudo. Emys. Trionyx. Chelonia. Platemys. Crocodilus. Gavialis. Monitor. Palæophis. Paleryx. —— All extinct species.	Testudo. Emys. Trionyx. Chelonia. Colossochelys. Crocodilus. Ophis. Coluber. Rana. Pipa. Bombinator. Andrias. Salamandra. Triton. —— All extinct species, except one Indian Crocodile and Tortoise.	The few species known are identical with existing forms.
BIRDS.								
		Foot-steps of Birds.		Fragments of undetermined Birds in Stonesfield oolite.	Cimoliornis and others undetermined?	Lithornis. Carbo. Pelecanus. Pelidna. Scolopax. Numenius. Pandion. Protornis.	Remains of Birds of existing genera.	The species known apparently existing forms, except the genus Dinornis, and some allies.

PISCES.

The remains of Fishes in British Silurian strata are obscure, and consist chiefly of species supposed to have belonged to the Placoid order. The genus *Onchus*, specimens of which are supposed to have occurred in both lower and upper Silurians, is an example.

The old red sandstone is a great store-house of fossil fishes. All the species are either Ganoids or Placoids. Of the former above sixty species have been described, chiefly by Agassiz. These belong to twenty-six genera.—*(See tables engraved on Map.)*

The number of our Fishes of the carboniferous epoch is very great. Many, however, still remain to be described. Twenty-four species of Sauroid Fishes are among those enumerated; twelve of Ganoid, and nearly a hundred of Placoid. The limestones of Bristol, Armagh, and the Hook-point, in Wexford county, are rich localities for carboniferous Fishes.

The British Permian Fishes are sixteen.—*(See Map.)*

In the upper new red sandstone, or trias, we find sixteen species of Placoid and seven of Ganoid Fishes.

The oolites, especially the lias, are rich in remains of Fishes. The principal genera are, among Placoids, *Hybodus*, with sixteen species; *Acrodus* (8), *Strophodus* (5), and *Chimæra* (11). Among Ganoids, *Dapedius* has six British representatives, *Tetragonolepis* (12), *Lepidotus* (10) *Pholidophorus* (11), *Eugnathus* (10), *Pachycormus* (9), and *Pycnodus* (8).

In the Wealden, species of *Acrodus*, *Hybodus*, and *Sphenonchus* occur among Placoids; and of *Tetragonolepis*, *Lepidotus*, *Pholidophorus*, *Ophiopsis*, *Gyrodus*, and *Pycnodus*, among Ganoids.

In our cretaceous rocks Placoid Fishes are most numerous. Between thirty and fifty species are recorded. The genera *Ptychodus* and *Chimæra* (or an allied type) are most prolific in species. Between fifteen and twenty Ganoids occur, *Gyrodus* and *Pycnodus* being the principal genera. Of *Ctenoids*, there are six species, and of *Cycloids* twelve species, belonging to nearly as many generic types.

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[1] For the fossil British Mammalia of this and other periods, Professor Owen's "History of British Fossil Mammals and Birds" should be consulted.

[2] See Owen's Reports, in Reports of British Association.

The British eocene species have been recently carefully worked by Agassiz. *(See table on map for general results.)* Among the Placoids, the genus *Myliobates* is most developed. Among the Ganoids, *Phyllodus*; the twelve eocene Ctenoids belong to eleven genera, and the Cycloids are nearly as numerous as to genera as species, of which there are between thirty and forty.

Our knowledge of the Fishes of the epoch of our upper tertiaries is as yet very imperfect. The *Zygobates Woodwardii*, the *Raia antiqua*, and the *Platax Woodwardii*, are the principal recorded forms. In fresh-water beds of the pleistocene epoch, remains of the pike, *Esox lucius*, have been found. It is the only British fossil Fish identical with our existing species.

Abroad, numerous old red sandstone Fishes occur in Russia, where also the Permian species have chiefly been observed. The marly slates of St. Cassian, in the Tyrol, furnish numerous Fishes, supposed to be of triassic age. Numerous oolitic and cretaceous Fishes have been found on the Continent. Of the latter age are the famous slates of Glaris, which have all the aspect of ancient rocks, but abound in organic remains evidently cretaceous. About forty species of fossil Fishes have been found in that locality. With the exception of the eocene, foreign tertiaries are much richer in Ichthyic remains than those of the British Isles. The miocene and pliocene formations of Southern Europe and Western Asia are rich in such remains. From them, and from deposits in Germany, species of thirty-seven genera are recorded. In the Indian newer tertiaries, numerous fresh-water Fishes have been found, related generically to existing forms of the region. In the pleistocene beds of North America the Capelan, *Mallotus villosus*, is found in a fossil state.

For the study of fossil Fishes the works of Professor Agassiz should be consulted. The finest collections are those of the Earl of Enniskillen and of Sir Philip Grey Egerton. The following table exhibits the names and distribution of the majority of described genera:—

SILURIAN.	CARBONIFEROUS.	PERMIAN.	OOLITIC.	CRETACEOUS.	OLDER TERTIARY.	NEWER TERTIARY.
Onchus ?	Amblypterus.	Dorypterus.	Coccolepis.	Beryx.	Labrax.	Perca.
Cochliodus ?	Palæoniscus.	Amblypterus.	Tetragonolepis.	Hoplopteryx.	Lates.	Smerdis.
	Platysomus.	Palæoniscus.	Dapedius.	Sphenocephalus.	Smerdis.	Cottus.
	Eurynotus.	Platysomus.	Amblypterus.	Acrogaster.	Dentex.	Platax.
	Dipterus.	Pygopterus.	Semionotus.	Acanus.	Sargus.	Mallotus.
DEVONIAN.	Diplopterus.	Acrolepis.	Lepidotus.	Podocis.	Cottus.	Silurus.
	Acanthodes.	Cœlacanthus.	Pholidophorus.	Fistularia.	Holocanthus.	Labrus.
Pterichthys.	Pygopterus.	Acrodus.	Notosomus.	Enchodus.	Macrostoma.	Tinca.
Pamphractus.	Acrolepis.	Janassa.	Ophiopsis.	Tetrapturus.	Cybium.	Cyclurus.
Homothorax.	Megalichthys.	Globulodus.	Notagogus.	Hypsodon.	Goniognathus.	Leuciscus.
Placothorax.	Graptolepis.	Dictæa.	Propterus.	Saurocephalus.	Hemirhynchus.	Aspius.
Polyphractus.	Pododus.	Gyropristis.	Leptolepis.	Saurodon.	Tetrapterus.	Rhodeus.
Chelyophorus.	Orognathus.	Byzenos.	Aspydorynchus.	Cladocyclus.	Cœlorhyncus.	Cobitis.
Coccosteus.	Cœlacanthus.	Radamas.	Belonostomus.	Istieus.	Sphyrænodus.	Acanthopsis.
Cephalaspis.	Hoplopygus.		Caturus.	Osmerus.	Hypsodon.	Lebias.
Acanthodes.	Uronemus.		Pachycormus.	Osmeroides.	Sphenolepis.	Esox.
Diplacanthus.	Holoptychius.	TRIASSIC.	Sauropsis.	Acrognathus.	Megalops.	Sphenolepis.
Cheirolepis.	Phyllolepis.		Eugnathus.	Aulolepis.	Notæus.	Clupea.
Cheiracanthus.	Carcharopsis.	Amblypterus.	Conodus.	Halec.	Lepidotus.	Anguilla.
Dipterus.	Cladodus.	Gyrolepis.	Ptycholepis.	Anenchelum.	Pycnodus.	Pycodus.
Osteolepis.	Diplodus.	Palæoniscus.	Saurostomus.	Nemopteryx.	Periodus.	Diodon.
Diplopterus.	Orodus.	Saurichthys.	Amblysemius.	Palymphyes.	Gyrodus.	Ischyodon.
Glyptopomus.	Ctenoptychius.	Cœlacanthus.	Megalurus.	Archæus.	Phyllodus.	Edaphodon.
Stagonolepis.	Chomatodus.	Pycnodus.	Macrosemius.	Vomer.	Glyptocephalus.	Passalodon.
Glyptolepis.	Psammodus.	Sphærodus.	Thrissops.	Isurus.	Accipenser.	Carcharodon.
Phyllolepis.	Helodus.	Placodus.	Gyrosteus.	Pleionemus.	Elasmodus.	Sphyrna.
Holoptychius.	Cochliodus.	Colobodus.	Ctenolepis.	Palæorhynchum.	Psalodus.	Corax.
Actinolepis.	Ctenodus.	Hybodus.	Undina.	Clupea.	Edaphodon.	Galeocerdo.
Platygnathus.	Pœcilodus.	Strophodus.	Sphærodus.	Lepidotus.	Glyphis.	Hemipristis.
Dendrodus.	Pleurodus.	Acrodus.	Pycnodus.	Belonostomus.	Carcharodon.	Notidanus.
Lamnodus.	Pleuracanthus.	Ceratodus.	Gyrodus.	Pomognathus.	Notidanus.	Otodus.
Cricodus.		Nemacanthus.	Gyroconchus.	Caturus.	Otodus.	Oxyrhina.
Asterolepis.		Leiacanthus.	Strobodus.	Macropoma.	Oxyrhina.	Lamna.
Bothriolepis.			Microdon.	Pycnodus.	Lamna.	Hybodus.
Psammosteus.			Chondrosteus.	Acrotemnus.	Pristis.	Pristis.
Homacanthus.			Ischyodon.	Sphærodus.	Myliobates.	Ætiobatis.
Hoplacanthus.			Ganodus.	Gyrodus.	Ætiobatis.	Zygobates.
Odontacanthus.			Psittacodon.	Dercetis.	Ptycacanthus.	Myliobates.
Narcodes.			Thyellina.	Acanthoderma.		Cyclobatis.
Naulas.			Anthropterus.	Acanthopleura.		Thaumaturus.
Byssacanthus.			Lamna.	Ischyodon.		
Onchus.			Notidanus.	Psittacodon.		
Ptychacanthus.			Ællopis.	Carcharias.		
Ctenacanthus.			Oxyrhina.	Corax.		
Climatius.			Hybodus.	Galeocerdo.		
Parexus.			Sphenonchus.	Hemipristis.		
Cosmacanthus.			Acrodus.	Notidanus.		
Ctenodus.			Ceratodus.	Otodus.		
Ctenoptychius.			Leptacanthus.	Oxyrhina.		
Cladodus.			Myriacanthus.	Lamna.		
			Asteracanthus.	Scylliodus.		
			Nemacanthus.	Thyellina.		
			Pristacanthus.	Hybodus.		
			Strophodus.	Cestracion.		
			Squaloraia.	Strophodus.		
			Cyclarthrus.	Acrodus.		
			Asterodermis.	Ptychodus.		
			Euryarthra.	Phacodus.		
			Thaumas.	Pachyrhizodus.		
			Aellopos.	Homonotus.		
			Asthalion.	Berycopsis.		

MOLLUSCA.

CEPHALOPODA.

In a geological point of view, the Molluscous division is probably that class of animals the fossil remains of which are most important in guiding us to conclusions respecting the age of sedimentary strata, and the conditions under which they were deposited. Generally speaking, the shells of Molluscs afford a certain clew to the nature and relation of the creatures which originally formed them. Their abundance, wide and marked diffusion, and the very perfect manner in which they are frequently preserved, render them valuable aids to the geologist.

The greater part of fossil Mollusca belongs to genera which are still represented among living animals. These genera, however, have very various ranges in time—some dating back to the epoch of the oldest sedimentary fossiliferous rocks, others, comparatively of very recent origin. Rarely do we find members of any genus preserved in formations widely apart, without there being allied forms of the same group in the intermediate formations. A few genera are confined to a single epoch—more range through several, but become extinct before the commencement of the present era. Such genera are usually of palæozoic origin, or have their maxima of development during the earliest geological ages. It would appear that the highest groups of shelled Molluscs were most developed, numerically, during the earlier epochs; so also were the Brachiopoda; whilst the Gasteropoda and Conchifera increased in numbers during the later periods, and as they approached the present. Our knowledge of the habits of existing Mollusca would lead us to the inference, that the cause of this phenomenon is to be sought in the destruction of the shallow-water deposits formed during the remoter epochs, and the preservation of strata of deep-sea origin. For, in the former, the Gasteropoda and Lamellibranchiata would be most likely to be preserved, and in the latter the Cephalopoda, Pteropoda, and Brachiopoda.

During the Silurian epoch many genera and species of Cephalopods inhabited the British seas.

The genus *Orthoceras*, the forms and size of whose species would lead us to infer that they were oceanic creatures, and inhabitants of deep seas, were especially abundant. Nearly forty British Silurian Orthoceratites are recorded, and there are many species in collections as yet unpublished. *Phragmoceras* and *Gomphoceras* were allied genera, very characteristic, also, of this epoch. Many forms of *Lituites*, and a few of Nautilus, accompanied them. In Devonian strata, also, we find *Orthoceratites* abundant, and the genera *Clymenia*, *Cyrtoceras*, and *Goniatites*, greatly developed. The last named genus becomes enormously developed, comparatively, in the carboniferous limestones, playing the part in the palæozoic epoch which Ammonites afterwards played in the secondary. At the same time *Nautili* were very abundant; and the genus presented many peculiar modifications, or sub-genera, characteristic of the time; whilst *Orthoceras* was also fully represented, the allied genus *Actinoceras*, appeared and disappeared. *Cyrtoceras* and *Phragmoceras* became almost extinct. Most of the genera above mentioned are peculiar to the palæozoic epoch as a whole, and eminently distinguish the sedimentary strata of that age from after-formations.

With the commencement of the secondary epoch, a new series of Cephalopods appeared in the seas of our area. The palæozoic genera, with the exception of *Nautilus*, had disappeared. We get in the lias the first remains of cuttle-fishes, resembling in general habits those which now live. The Belemnites appear and become very abundant, giving a well-marked character to secondary palæontology. Peculiar modifications of the genus *Hamites*, which have received the name *Ancyloceras* and *Crioceras*, commenced. Above all, the genus *Ammonites* came into existence, and rapidly attained an enormous development, far beyond that of any other group of Cephalopoda, whether fossil or recent. Peculiar forms of *Ammonites* distinguished the earlier from the later oolitic formations, and afford admirable clews for the identification of secondary strata far apart.

The Ammonites continued during the cretaceous epoch, and were very abundant till its close, when they finally disappeared. The genus *Hamites* attained a great development; and in Britain the species are chiefly to be found in the gault. *Scaphites* became a prominent and characteristic genus. *Belemnites* remained, but greatly diminished in numbers. *Turrilites*, *Baculites*, and *Ptychoceras* especially characterized the latter half of the secondary epoch. *Nautilus* assumed forms closely resembling those of the very few existing species.

In our eocene marine tertiaries the testaceous Cephalopods are reduced to a few species of *Nautilus*; one of which, the *Nautilus zigzag*, is remarkable for its affinities with certain palæozoic forms. No Nautili have been found in any of the crag deposits; and we have reason to believe that after the eocene period, no testaceous Cephalopods ranged to our seas. It is likely, however, the cuttle-fishes of which we find eocene remains, were not uncommon during the miocene and pliocene epochs, and probably, also, during the pleistocene.

The arrangement of the Ammonites in natural groups, as proposed by Baron Von Buch, is so important in a geological point of view, as well as zoologically, that we introduce it here. The evidence it affords of modifications of forms, even in a single genus, having reference to epochs in time, indicates a much more valuable principle for the determination of the relations of fossiliferous beds, geographically far apart and disconnected, than that of their identification by means of identical species. Identical species in distant beds far apart, rather indicate that such beds are not synchronic; for every species must have time given it for its diffusion.

The following is an outline of Von Buch's classification of Ammonites, as modified by Alcide D'Orbigny.[1] *(See figures of the types on the map.)*

A.—Species with an entire dorsal keel.

Group I. *Arietes.* (Von Buch.)—Sides of shell ornamented with simple radiating ribs. Back squared, and furnished with a median keel, in which the siphon is placed. Mouth beaked. Partition-sutures formed of unsymmetrical lobes and saddles. Dorsal lobe as deep as broad, and longer than the superior lateral. Dorsal saddle very short, the lateral one very long.

Species peculiar to the lias (lower beds).

Group II. *Falciferi.* (Von Buch.)—Shell compressed, the sides ornamented with bent folds without tubercles. Back sharp and prominent, keeled. Dorsal saddle very long. Lateral lobe always much longer than the dorsal lobe. Saddles almost symmetrical.

Upper beds of the lias.

Group III. *Cristati.* (D'Orbigny.)—Shell compressed, ornamented with bifurcated bent ribs, which sometimes bear tubercles. Back prominent, keeled. Dorsal edge of the mouth prolonged into a beak, when the shell is full grown. Lobes and saddles usually symmetrically divided. The lateral less elevated than the other saddles.

Cretaceous. In the lower green sand, gault, and upper green sand.

Species with the back channelled.

Group IV. *Tuberculati.* (D'Orbigny.)—Shell with lateral ribs and tubercles, which alternate on the two sides of the back. Back excavated centrally by a deep canal. Mouth complete, rostrated dorsally. Lobes and saddles divided unsymmetrically. Dorsal lobe shorter than the superior lateral, and as narrow as the dorsal canal.

Gault and upper green sand.

Species with the back sharp, but not keeled.

Group V. *Clypeiformi.* (D'Orbigny.)—Shell compressed, usually smooth, or slightly wrinkled at the sides. Back very sharp. The last whorl usually embracing all the others. Partition-sutures divided into numerous lobes unsymmetrically branched, and saddles symmetrically branched.

Neocomian, gault, and upper green sand.

Species with the back prominent and crenated.

Group VI. *Amalthei.* (Von Buch.)—Shell ornamented on the sides with gentle arcuated ribs; the back sharp and transversely crenated. Mouth beaked dorsally. Lobes and saddles divided unsymmetrically. Dorsal lobe shorter than the superior lateral.

Oolites.

Group VII. *Rhotomagenses.* (D'Orbigny.)—Shell with inflated, squared, or oval whorls, ornamented with prominent ribs, which bear several ranges of tubercles, one row being on the centre of the back. Lobes and saddles symmetrically divided. Dorsal lobe longer than the superior lateral.

Gault and upper green sand.

Group VIII. *Pulchelli.* (D'Orbigny.)—Shell with prominent, straight ribs on two sides, passing over the back, upon which they form a crest. Lobes symmetrical; saddles unsymmetrical. Dorsal lobe equal to the superior lateral.

Gault and lower green sand.

Species with the back excavated, and the sides tuberculated.

Group IX. *Dentati.* (Von Buch.)—Shell more or less inflated; ribbed at sides; ribs often bifurcated, and tuberculated round the umbilicus; their extremities prominent on each side of the hollowed-out back. Lobes divided unsymmetrically; saddles symmetrically.

Neocomian, or lower green sand, and gault.

Group X. *Ornati.* (Von Buch.)—Shell slightly inflated; back narrow, bordered with tubercles; another range of tubercles on the middle of the sides of the whorls. Lobes and saddles unsymmetrically divided. Dorsal lobe always very much shorter than the superior lateral.

All Oxford clay species.

Species with the back more or less squared.

Group XI. *Flexuosi.* (Von Buch.)—Sides of shell with a row of tubercles round the umbilicus, and another on each side of the back, the centre of which is slightly prominent. Lobes and saddles unsymmetrically divided. Dorsal lobe shorter than the superior lateral, which is very large.

All neocomian species.

Group XII. *Compressi.* (D'Orbigny.)—Shell generally much compressed with enveloping whorls, which are ribbed or striated on the side. The ribs or striæ slightly arcuated, and forming tubercles on the sides of the back, which is narrow and truncated. Lobes unsymmetrically, saddles symmetrically divided. Dorsal lobe very large, much longer than the superior lateral.

Upper green sand.

Group XIII. *Armati.* (Von Buch.)—Shell with squared whorls, the back bordered on each edge by a range of tubercles; other ranges on the sides. Back broad. Lobes unsymmetrically, saddles symmetrically divided. Dorsal lobe longer, or equal to the superior lateral, which is placed on the middle of the sides of the whorl, and is always narrower than the dorsal saddle.

Upper beds of the oolites.

Group XIV. *Angulicostati.* (D'Orbigny.)—Shell thick, with nearly round whorls. Back narrower than the sides, which are ornamented with elevated ribs crossing the back. Lobes unsymmetrically, saddles usually symmetrically divided. Dorsal lobe shorter than the superior lateral.

Lower green sand and gault.

Group XV. *Capricorni.* (Von Buch.)—Shell with very convex whorls, ornamented with simple strait plain ribs. Back broad; wider than the sides. Lobes unsymmetrically, saddles symmetrically divided. Dorsal lobe longest.

Oolitic.

Species with the back rounded, convex.

Group XVI. *Heterophylli.* (D'Orbigny.)—Shell compressed, the whorls enveloping. Sides smooth, slightly striated or furrowed. Back very convex, and not very broad. Lobes much ramified, unsymmetrically divided: the saddles mostly symmetrically. Dorsal lobe almost always shorter than the superior lateral.

Those with unsymmetrical saddles are few, and are oolitic (as A. heterophyllus); the others are from the lower part of the cretaceous system.[1]

Group XVII. *Ligati.* (D'Orbigny.)—Shell compressed, generally smooth, or slightly undulated, and marked at intervals with varices and channels. Back convex, sometimes slightly compressed. Lobes unsymmetrically divided; saddles usually symmetrical.

All cretaceous.

Group XVIII. *Planulati.* (Von Buch.)—Discoidal, whorls cylindrical, striated or closely ribbed partially. Lobes divided unsymmetrically; the saddles symmetrically. The auxiliary lobes very oblique, and turned towards the umbilicus.

Cretaceous; the lowest beds.

Group XIX. *Coronarii.* (Von Buch.)—Distinguished from the Planulati by the presence of a tubercle at the point of bifurcation of the striæ or ribs.

Lower oolitic strata.

Group XX. *Macrocephali.* (Von Buch.)—Like the Coronarii, but more inflated, and having the tubercles, instead of being placed mid-way on the side of the whorl, projecting near the umbilicus.

Jurassic and neocomian.

Group XXI. *Fimbriati.* (D'Orbigny.)—Discoidal; whorls cylindrical, contiguous and not enveloping, smooth, or with distant varices. Mouth circular. Lobes and saddles symmetrically divided; broad at the extremities, narrow at their bases.

Lias and lower green sand.

TABLE OF THE DISTRIBUTION IN TIME OF THE PRINCIPAL GENERA OF CEPHALOPODA.

Cephalopoda.	Lower Palæozoic.	Upper Palæozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Present.
Sepia,	…	…	*	…	*	*	*
Sepioteuthis,	…	…	*				
Ommatostrephes,	…	…	*				
Kelæno,	…	…	*				
Beloptera,	…	…	…	…	*		
Onychoteuthis,	…	…	*				
Teudopsis,	…	…	*				
Spirulirostra,	…	…	…	…	…	*	
Belemnites,	…	…	**	*			
Orthoceras	**	**	*				
Actinoceras,	…	*					
Cyrtoceras,	*	**					
Phragmoceras,	**	*					
Gomphoceras,	**	*					
Clymenia,	…	**					
Lituites,	**	*	…	…			
Nautilus,	*	**	*	*	*	*	*
Goniatites,	*	**	*				
Ceratites,	…	…	*				
Ammonites,	…	…	***	**			
Scaphites,	…	…	*	*			
Turrilites,	…	…	*	**			
Hamites,	…	…	*	**			
Baculites,	…	…	…	*			
Ptychoceras,	…	…	…	*			

HETEROPODA.

The genus *Bellerophon*, confined to rocks of palæozoic age, and especially abundant in those of the Silurian system, is supposed to belong to this division of Mollusca. All existing Heteropoda are free swimmers, and are found chiefly in the open sea, especially where it is of great depth.

PTEROPODA.

This is also an order of pelagic and swimming Mollusca. They appear to have inhabited the earliest seas; for there can be little question that the palæozoic genus *Conularia* was a Pteropod nearly allied to *Cleodora*. Species of *Conularia* are found in Silurian, Devonian, and Carboniferous strata. In Silurian rocks of various stages, impressions of shells resembling *Orthoceras* in form, but presenting no trace of chambers, are found often abundantly; these were, probably, gigantic Pteropods, closely allied to, if not generically identical with, the existing *Creseis*. The palæozoic genus *Theca* seems also to have been a member of this order. In our oolitic and cretaceous strata we find no traces of Pteropoda. A species of *Cleodora* has been found in our upper tertiaries; abroad other species have occurred in corresponding formations, along with *Creseis*, *Cuvieria*, and *Hyalæa*.

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[1] See his Paléontologie Française, Ter. Cret, vol. i.

[1] The group *Lævigati*, indicated by E. Forbes in the account of the Ammonites of Southern India (Geological Transactions, new series, vol. vii.), differs from the Heterophylli in the back, which is furnished with a slightly elevated keel.

Many living species of Pteropoda are unprovided with shells. Numerous similar forms might have existed at former periods in the earth's history, and yet have left not a trace to bear witness of their ancient being.

GASTEROPODA.

The Gasteropoda of the British Silurians are comparatively few, and often very obscure. Many of them have been referred to existing genera, though with great uncertainty. *Natica*, *Capulus* (*Acroculia* of Phillips), and *Chiton* (*Helminthochiton Griffithii* of Salter), are almost all the Silurian genera which appear truly of the same types with existing assemblages of species. The names *Littorina*, *Nerita*, *Patella*, *Trochus*, *Turbo*, and *Turritella*, have been applied to Silurian fossils respecting the true position of which there is reason to entertain many doubts. The genus *Loxonema* seems synonymous with, or, at any rate, closely allied to, the modern *Chemnitzia*. *Macrocheilus* seems to have been a true and peculiar palæozoic type. Under the heads of *Murchisonia*, *Pleurotomaria*, and *Euomphalus*, Mollusca of more orders than one have probably been included.

The same remarks apply to the reputed Gasteropods of the Devonian formation, where we find also fossils which have been referred, but with equal doubt, to the existing genera *Buccinum* and *Murex*. The *Loxonema* group of *Chemnitziæ* is greatly developed in this part of the geological series, as also in the carboniferous rocks. In the latter, *Pleurotomaria* and *Euomphalus* play an important part. The British carboniferous shells which have been referred to *Umbrella*, *Trochella*, *Terebra*, *Siphonaria*, *Lacuna*, *Elenchus*, and *Fissurella*, are of very doubtful generic relations. The number of reputed British Gasteropoda of the carboniferous epoch far exceeds that of previous formations.

In oölitic rocks we find numerous well-marked Gasteropods. There can be little doubt here of the true relationship of the *Trochi*, *Turbines*, *Rissoæ*, *Rimulae*, *Rostellariæ*, *Naticæ*, *Turritella*, *Chemnitziæ*, *Bullae*, *Dentalia*, *Tornatellae*, and *Emarginulæ*, with the existing genera which bear those names. The preservation of the shallow-water marine oolitic deposits has enabled us to judge of the extent of the oolitic Gasteropodous fauna. During this epoch the genus *Nerinæa* very characteristic of the time, appeared. *Pleurotomariæ* were very abundant. In the Purbeck and Wealden fresh-water strata we find members of the genera *Melanopsis*, *Neritina*, *Paludina*, *Physa*, *Planorbis*, *Limneus* and *Valvata*, many of them nearly allied to existing forms. In many parts of the cretaceous group Gasteropods occur, without doubt members of existing genera. Here we have the final appearance of *Nerinæa*. The London clay Gasteropods are still more numerous, and more nearly allied to existing forms, but not identical. The genera *Bulla*, *Cerithium*, *Conus*, *Fusus*, *Natica*, *Murex*, *Pleurotoma*, *Solarium*, and above all, *Voluta*, had a great development within our area during the eocene period, and were associated with representatives of many other genera, the existing species of which are tropical, or subtropical. In the coralline crag the existing Gasteropoda of the British seas begin to appear, but very scantily. The number, however, increases rapidly in the red crag, and all, or almost all, that are found in the pleistocene beds are existing species of the North Atlantic.

Many Gasteropods occur in the fresh-water beds of the tertiary epochs. Thus in the Isle of Wight fresh-water eocene strata, we find no fewer than six species of *Limneus*, six of *Melania*, as many of *Melanopsis* and *Planorbis*, and several *Paludinae* and *Neritinae*. In the fresh-water upper tertiaries most of the species are existing British forms; but there are also some apparently extinct, as the *Valvata antiqua*.

Abroad the palæozoic strata do not present many important generic additions to those enumerated in the British list. The Continental oolites also present a similar assemblage of Gasteropodous genera with that which characterizes our British beds of the same age. In France the cretaceous rocks present more numerous and varied Gasteropods than the English; and the cretaceous deposits of Southern India, which appear to have been deposited in a moderate depth of water, abound in Gasteropods, associated generically very nearly as they are in tropical seas at present. Tertiary strata of all ages, and in all parts of the world, furnish numerous genera and species of this order of Molluscs, mostly related to existing types.

TABLE SHOWING THE DISTRIBUTION IN TIME OF THE PRINCIPAL GENERA OF GASTEROPODA.

Mollusca Gasteropoda.	Lower Palæozoic.	Upper Palæozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Present.	Habitat of the Genus
PULMONIFERA.								
Limax,	...	...	...	...	...	•	••	Terrestrial.
Helix,	...	...	...	...	•	•	•••	Do.
Bulimus,	...	...	...	...	•	•	•••	Do.
Pupa,	...	...	...	...	...	•	•••	Do.
Clausilia,	...	...	...	...	...	•	•••	Do.
Limneus,	...	...	•	•	•	•	••	Inhabits fresh water.
Physa,	...	...	•	...	•	•	••	Do.
Planorbis,	...	...	•	•	•	•	••	Do.
Ancylus,	...	...	...	...	•	•	•	Do.
Auricula,	...	...	...	...	...	•	•	Brackish water, and margin of the sea.
PECTINIBRANCHIATA.								
Bulla,	...	...	•	•	•	•	••	Marine; various depths on sand and mud.
Bullaea,	...	...	...	...	...	•	••	On muddy ground in sea; and swimming.
Aplysia,	...	...	...	...	...	•	••	Do.; usually in shallows.
Tornatella,	...	...	•	•	•	•	•	On sand in sea; shallow and deep.
Natica,	•	•	•	••	••	••	•••	On sand and among gravel in sea; various depths.
Narica,	...	...	...	•				?
Sigaretus,	...	•?	...	...	•	•	•	Shallows, and moderate depths.
Velutina,	...	...	...	...	...	•	•	Usually rather deep water.
Marsenia,	...	...	...	...	...	•	•	Shallows, and moderate depths.
Avellana,	...	...	...	•				?
Paludina,	...	...	•	•	•	•	••	Fresh water.
Valvata,	...	...	•	...	•	•	•	Do.
Cyclostoma,	...	...	...	...	•	•	•••	Terrestrial.
Littorina,	•?	•?	•?	•?	•	•	••	On rocks, &c., above low-water mark.
Litiopa,	•?	•?	...	...	...	•?	•	On wrack in open ocean.
Planaxis,	...	...	...	...	...	•	•	Littoral.
Rissoa,	...	...	•	•	•	••	•••	On wood chiefly in shallow seas, but ranging deep.
Melanopsis,	...	...	•	•	•	•	•	Fresh water, usually of warm climates.
Melania,	...	...	•	•	•	•	••	Do. do.
Turritella,	•?	•?	•	•	•••	••	••	Marine; sublittoral, and ranging deep; mud.
Scalaria,	...	•?	•	•	••	••	••	Marine; various depths; usually sand.
Alvania,	...	...	...	...	...	•	•	Marine; moderate depths.
Chemnitzia,	•	•	•	•	•	•	•	Shallows, to very deep water.
Eulimella,	...	...	...	...	...	•	•	Do.
Odostomia,	...	...	...	...	...	•	•	Do.
Nerinæa,	...	...	••	••				?
Pyramidella,	...	...	...	•	•	•	•	Shallows.
Bonellia,	...	...	...	•	•	•	•	Various depths.
Eulima,	•	•	•	•	•	•	•	Shallows, and considerable depths.
Macrocheilus,	•	•						?
Ringicula,	...	...	...	...	•	•	•	Shallows.
Erato,	...	...	...	...	...	•	•	Various depths.
Volvaria,	...	...	...	...	•	...	•	Shallows.
Marginella,	...	...	...	...	•	•	•	?
Cypræa,	...	...	...	•	•	•	•••	Mostly littoral, or sublittoral, and tropical.
Ovula,	...	...	...	...	•	•	•	Do.
Oliva,	...	...	...	•	•	•	•••	Do.
Ancillaria,	...	...	...	...	•	•	•	Do.
Terebellum,	...	...	...	...	•	•?	•	Do.
Conus,	...	...	•	•	•	•	•••	Do.
Voluta,	...	...	...	•	•••	•	••	Do.
Mitra,	...	...	...	•	•	•	•••	Do. Ranges deep.
Columbella,	...	...	...	...	...	•	••	Do.
Strombus,	...	...	...	•	•	•	••	Do.
Pterocera,	...	...	•	•	•	•	••	Do.
Rostellaria,	...	...	•	•	•	•	•	Do. Northern species in deep sea.
Pterodonta,	...	...	...	•				?
Struthiolaria,	...	...	...	...	...	•	•	Moderate depths?
Murex,	...	...	•	•	•	•	••	Shallows, and moderate depths.
Ranella,	...	...	•	•	•	•	••	Shallows.
Triton,	...	...	...	•	•	•	••	Do. Rocky places.
Fusus,	...	•	•	•	••	•	••	Various depths; some very deep-sea forms.
Pyrula,	...	...	...	•	••	•	•	Shallows.
Fasciolaria,	...	...	...	...	•	•	•	Do. Rocky places.
Pleurotoma,	...	...	...	...	•••	••	••	Various depths from 0 to very deep sea.
Turbinellus,	...	...	...	...	•	•	•	Shallows and moderate depths.
Cancellaria,	...	...	...	...	•	•	•	Moderate depths.
Cassidaria,	...	...	...	...	•	•	•	Shallows?
Cassis,	...	...	...	...	•	•	•	Shallows and moderate depths.
Harpa,	...	...	...	...	•	...	•	Do. do.
Dolium,	...	...	...	•?	...	•	•	Do. do.
Trichotropis,	...	...	...	...	...	...	•	Mostly deep sea and northern.
Buccinum,	...	...	•	•	•	•	•	Various depths; genus not rightly bounded.
Nassa,	...	...	...	•	•	••	•••	Mostly littoral and sublittoral.
Purpura,	...	...	...	...	...	•	•••	Littoral; on rocks.
Terebra,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral, and moderate depths.
Cerithium,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Mostly littoral and sublittoral, but ranging very deep.
Murchisonia,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Marine.
Pleurotomaria,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Marine; probably several distinct tribes under this name.
Scissurella,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Marine.
Cirrus,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Marine.
Haliotis,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral.
Stomatia,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Moderate depths.
Nerita,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral or sublittoral.
Phorus,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Moderate depths.
Trochus,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Marine; various depths; the majority littoral.
Rotella,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral.
Solarium,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral, and sublittoral.
Delphinula,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Do. do.
Turbo,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral, and ranging to great depths.
Phasianella,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral, and sublittoral.
Magilus,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	In corals.
Vermetus,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Chiefly in rocks, and littoral.
Cæcum,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Various depths.
Siliquaria,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Deep water.
Emarginula,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Marine; shallow water to great depths.
Rimula,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Do.
Parmophorus,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral; on rocks.
Fissurella,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral, and ranging deep.
Siphonaria,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral, on rocks.
Lottia,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Littoral, and ranging to deep sea.
Capulus,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Marine; mostly deep sea.
Calyptræa,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Marine; sublittoral.
Infundibulum,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Do.
Crepidula,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Marine; littoral.
Dentalium,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Ranges to great depths in sand and mud.
CYCLOBRANCHIATA.								
Patella,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Mostly littoral.
Chiton,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Most littoral, but ranging deep in sea.

CONCHIFERA—LAMELLIBRANCHIATA.

Lamellibranchiate Bivalves are comparatively very scarce in the palæozoic rocks of Britain. In the lower Silurians they are especially rare; in the upper, but few. Such as do occur, though presenting forms which enable us with probability to pronounce on their relationship with existing genera, are still not in a condition to place that relationship beyond a doubt. Thus, though the Silurian shells referred to *Arca*, *Nucula*, and *Pectunculus* appear beyond question to be Arcaceæ, they present peculiarities of form and structure which would rather indicate that they are specific types, linking those genera with each other, than true members of them. The group of shells referred to *Cypricardia*, very characteristic of certain upper Silurian strata, appear to have no true relationship with that genus, but rather to have been members of the family *Mytilaceæ*, and allies of *Modiola*. The so-called *Pullastræ* are of like nature, and the Silurian shells called *Sanguinolaria* and *Sanguinolites*; under which latter name, indeed, all might be conveniently united. The curious extinct genera *Pleurorhyncus* and *Cardiola* are more certain. Numerous species of *Avicula* and allied shells, known as *Inoceramus*, *Posidonomya*, and *Pterinæa*, constitute the Silurian Monomyariæ, and some of those of the first named genus present a striking analogy with forms of *Avicula* now living.

In the Devonian rocks, the general assemblage of Conchifera is similar to that in the Silurians, and the same remarks apply. The genus *Pleurorhyncus* increases. The extinct genus *Megalodon* occurs. Well-formed *Pectens* appear, and are numerous in species (eight).

The number of Lamellibranchiata is greatly increased in the carboniferous limestones, especially those of Ireland. (See M'Coy's Synopsis.) These have been referred to numerous genera, many of them existing, but not always on reasonable grounds. Thus, the genera *Amphidesma*, *Anatina*, *Corbula*, *Lutraria*, *Mactra*, *Kellia*, *Crenella*, *Pandora*, *Psammobia*, *Artemis*, *Venerupis*, *Pullastra*, *Ungulina*, *Cyprina*, *Anomia*, *Meleagrina*, *Lithodomus*, *Corbis*, and *Donax*, are enumerated in British lists of carboniferous limestone fossils, though the evidence we have at present is quite insufficient to permit of our regarding those genera as palæozoic, and the numerous fossils which have been referred to them might with equal probability be referred to as many genera of other orders. Many of the new genera, such as *Leptodomus*, *Dolabra*, and *Sedgwickia*, are also very indistinct. It may, however, be said generally of the carboniferous Lamellibranchiata, that they present a marked advance towards existing forms. This is especially seen among the *Arcaceæ*. We know too little yet of Permian and triassic Lamellibranchiata to pronounce definitely on their generic relations. During the oolitic period, numerous well-marked genera appeared for the first time, many of them still existing, others extinct. The oolitic *Arcaceæ* have very definite relations with existing forms; so have the species of *Corbula*, *Pinna*, the *Mytilaceæ*, many of the *Venus* tribe, the *Lucinae*, *Astarte*, *Lima*, and *Crenatula*. The genera most developed in British strata, are *Pholadomya*, of which 19 species are enumerated, *Modiola* (17), *Arca* (23), *Nucula* (11), *Trigonia* (13), *Astarte* (22), *Cardinia* (12), *Cardium* (12), *Isocardia* (11), *Pecten* (31), *Lima* (23), *Gervillia* (10), and *Ostrea*, including *Gryphæa* (33). Some genera, of which there are few species, are also highly characteristic, as *Perna* (2), *Pholas* (2), *Panopæa* (several), *Opis* (2), *Myoconcha* (1), *Lysianassa* (4), *Hippopodium* (1), and *Corbis* (3.) In the fresh-water beds of the Purbecks and Wealden, numerous well-marked species of *Unio* occur with *Cyclas* and *Dreissena*. The British cretaceous *Lamellibranchiata* have considerable relations with oolitic forms, and in some few instances (as *Gervillia aviculoides*) appear to be identical. The greater number occur in the green sands, and indicate the formation of these beds (whether upper or lower) to have been in shallower water than that in which the chalk was deposited. The genera greatly developed are *Arca* (12), *Nucula* (11), *Trigonia* (12), *Venus* (17), *Inoceramus* (17), *Ostrea* with *Gryphæa* (20), *Lima* (12), and *Pecten* (14). The presence of true species of *Crassatella*, *Cyprina*, *Cardita*, *Solen*, and *Spondylus*, is worthy of note. *Pholadomya*, *Panopæa*, *Corbis*, *Corbula*, *Isocardia*, *Anomia*, *Avicula*, *Gervillia*, *Plicatula*, and *Perna*, have well-marked representatives among British cretaceous fossils. *Thetis* is a remarkable genus of this period.

The British eocene Bivalves have been carefully investigated by Mr. Edwards, and are of great interest, on account of the light they throw upon the climate of our area at the commencement of the tertiary period: So far as the most recently published lists afford information, the following is the state of this part of our eocene fauna:—

PHOLADIDÆ.—*Teredo* 2, *Pholas* 2, *Gastrochæna* 1, *Fistulana* 1, *Clavagella* 1, *Saxicava*, 1, *Petricola* 1.
CORBULIDÆ.—*Corbula* 13, *Neæra* 4, *Potamomya* 2.
MYADÆ.—*Mya* 1, *Panopæa* 2, *Pholadomya* 1.
ANATINIDÆ.—*Thracia* 2.
SOLENIDÆ.—*Solen* 4.
SOLENOCURTIDÆ.—*Solenocurtus* 1, *Glycimeris* 1.
TELLINIDÆ.—*Tellina* 21, *Mesodesma* 1, *Amphidesma* 1, *Psammobia* 3.
MACTRADÆ.—*Mactra* 4.
VENERIDÆ.—*Venus* 18, *Diplodonta* 1.
CYPRINIDÆ.—*Cyprina* 2, *Astarte* 4, *Cardita* 8.
CARDIADÆ.—*Cardium* 10, *Cardilia* 1, *Cypricardia* 3.
CYCLADIDÆ.—*Cyrena* 6.
LUCINIDÆ.—*Lucina* 16, *Corbis* 1.
KELLIADÆ.—*Kellia* 2, *Lepton* 1.
CHAMADÆ.—*Chama* 3, *Isocardia* 1.
ARCACEÆ.—*Arca* 6, *Nucula* 12, *Pectunculus* 5.
MYTILACEÆ.—*Mytilus* 7, *Dreissena* 1, *Perna* 3.
AVICULACEÆ.—*Avicula* 3.
PECTENIDÆ.—*Pecten* 9, *Lima* 1.
OSTREADÆ.—*Ostrea* 9, *Vulsella* 1.

None of the above is an existing British species.

In our upper tertiaries a considerable number of Lamellibranchiata occur. The majority of these are existing forms, which, numerous in our miocene beds, become still more numerous in the pliocene, and in the pleistocene the Conchifera are all, with two or three exceptions, identical with living species. The general character of the miocene Bivalves is Mediterranean, or rather Lusitanian: that of the pleiocene, mixed Mediterranean and northern: that of the pleistocene essentially boreal and arctic. In the last named formation several of the species are extinct in the British seas now, but still live in the arctic seas, or on the coasts of Boreal America. Of the forms altogether extinct, one very remarkable species of *Nucula* (the *Nucula Cobboldiæ*) appears to have been destroyed in consequence of the upheaval of the bed of the pleistocene German Ocean.

Several generic forms of *Lamellibranchiata* occur in foreign strata, of various ages, which are unrepresented in the rocks of Britain.

BRACHIOPODA.

The Palliobranchiate Mollusca play a very important part in the faunas of the several geological formations, especially of the older rocks. They seem anciently to have attained a development far exceeding that which the order now presents, and many generic types or subordinate groups have entirely disappeared. Such types are very important to the palæontologist, since they hold very definite relations to epochs in time, and consequently afford great assistance in the determination of the ages of rocks.

Brachiopoda were the earliest of animals in their appearance in time. Species of *Lingula*, a genus still existing, appear to have been the most ancient of Silurian animals. Other genera rapidly succeed, and the number of species found fossil in the upper and lower Silurians is very great. Considerably above 100 kinds are known in the British Silurians. Of these, the various forms of *Orthis* are among the most remarkable. About 50 British Silurian species of this genus are known. The genus *Leptæna*, of which we have about 20 British forms, is also very characteristic. *Pentamerus*, including but few species, is peculiarly Silurian. Not a few well-marked *Spirifers* are also found in these rocks, and between 40 and 50 of their fossils are recorded as species of *Terebratula* and *Atrypa*. Several well-marked species of Orbicula are of this age, and one *Crania*; also two or three species of *Productus*.

In the Devonian rocks, the number of species of *Spirifer* greatly increases. Between 30 and 40, thrice as many as there are in the Silurians, have been found. The genus *Strigocephalus* replaces *Pentamerus*. *Producti* double their number. *Orthides* greatly decrease. *Leptænæ* (and *Chonetes*) continue. *Terebratula* and *Atrypa* have numerous representatives. *Calceola* is peculiarly Devonian.

In our carboniferous limestones the *Spirifers* double their number, and the smooth section of this genus (*Martinia* of M'Coy) becomes highly developed and characteristic. *Productus* attains its maximum, and includes between 40 and 50 British forms. *Orthides* are as numerous as in the Devonian. *Leptænæ* have greatly decreased; but *Chonetes* attains its maximum. *Terebratulæ* are numerous and peculiar. *Crania*, *Lingula*, and *Orbicula*, have their representatives.

In the Permian the 23 forms of Brachiopods recorded are closely allied to the carboniferous, especially the species of Productus.

No Brachiopods have been found in our triassic strata.

In the oolites, a great change has taken place among this order of Molluscs, as compared with its palæozoic development. True *Terebratulæ* now prevail (between 40 and 50 recorded). Most of the characteristic palæozoic genera have disappeared, except *Spirifer* and *Leptæna*. *Crania*, *Lingula*, and *Orbicula*, are all present.

The cretaceous Brachiopods are mostly species of *Terebratula* (about 40 are recorded). Among these is a form, *Terebratula striatula*, not to be distinguished from the existing *Terebratula caput serpentis*. The other genera are *Magas*, *Lingula*, *Crania* (which attains a considerable development in the chalk), and *Orbicula*. In the cretaceous rocks we find the anomalous *Rudistes*, of which, however, we have only three forms in Britain.

The Brachiopods of our eocene beds are very few; *Lingula* (*tenuis*) and *Terebratula striatula* are the chief forms. In the upper tertiaries there is a *Lingula* in the coralline crag, wherein also occurs the existing *Crania Norvegica*. *Terebratula variabilis* is a large extinct red crag species; and *Terebratula psittacea*, identical with the existing form, occurs in the pleistocene and mammaliferous crag. Another species *Terebratula cistellula*, occurs in the crag, and has been very recently dredged alive on the coasts of Scotland.

TABLE SHOWING THE DISTRIBUTION IN TIME OF THE PRINCIPAL GENERA OF MOLLUSCA ACEPHALA.

Mollusca Acephala.	Lower Palæozoic.	Upper Palæozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Present.	Habitat of the Genus.
LAMELLIBRANCHIATA.								
Teredo,	...	...	...	•	•	•	•	Marine; bores in floating wood.
Pholas,	...	...	•	•	•	•	••	Marine; bores in rocks, clay, and wood.
Aspergillum,	...	...	...	...	...	•	•	Marine; burrows in sand; sub-littoral.
Clavagella,	...	...	...	•	•	•	•	Marine; bores in rocks, &c., to some depth.
Gastrochæna,	...	...	•	•	•	•	•	Do. do.
Saxicava,	...	...	...	...	•	•	•	Do. do., and free.
Petricola,	...	...	...	•	•	•	•	Shallows, and moderate depths; boring.
Venerupis,	...	...	•?	...	•	•	•	Do. do.
Pholadomya,	...	•	•••	••	•	•	•	Moderately deep water?
Panopæa,	...	...	•	••	••	•	•	Shallows.
Mya,	...	...	?	?	•	•	••	Shallows, littoral, and moderate depths.
Lutraria,	...	...	?	?	[illegible]	•	••	Do. do.
Glycimeris,	...	...	[illegible]	[illegible]	[illegible]	•	•	Do. do.

TABLE OF MOLLUSCA ACEPHALA—*Continued*

Mollusca Acephala.	Lower Palæozoic.	Upper Palæozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Present.	Habitat of the Genus.
Solemya,	…	•	…	…	…			Shallows, littoral, and moderate depths.
Solen,	…	•	…	…		•	•	Do. do.
Solenocurtus,	…	…	•?	•	•	•	••	Do. do.
Lyonsia,	…	…	•	•	•	•	•	Do. do.
Anatina,	…	…	•	…	…	•	•	Do. do.
Thracia,	…	…	…	•	•	•	•	Do. do., and deep sea.
Sphenia,	…	…	…	•	…	•	•	Do. do.
Corbula,	…	•	…	…	…	•	•	Do. do.
Neæra,	…	…	•	•	••	•	•	Shallows, to very deep sea.
Poromya,	…	…	•	…	•	•	••	Deep sea.
Pandora,	…	…	•	•	…	•	•	Shallows, to considerable depths.
Listera,	…	…	…	•	•	•	•	Littoral, in sand.
Amphidesma,	…	•?	•?	•	…	•	•	Various depths; from littoral to extremely deep sea.
Sanguinolaria,	…	•?		•?		•	•	Moderate depths.
Psammobia,	…	…	•	…		•		Moderate and considerable depths.
Tellina,	•?	•?	…	…	•	•	•	Littoral; Shallows, and considerable depths.
Donax,	…	…	…	•	•	•	•	Littoral.
Montacuta,	…	…	…	?	••	•	•	Various depths.
Mesodesma,	…	…	…	…	•	••	••	Littoral.
Mactra,	…	…	…	…	•	•	•	Littoral, and moderate depths.
Venus,	•?	•?	…	…	•	•	•	From littoral to very deep sea.
Cyprina,	…	…	•	•?	•	•	•	Shallows, and moderate depths.
Astarte,	…	…	…	•	•	…	•	From shallows to very deep sea.
Crassatella,	…	•	••	•	••	••	•••	Moderate depths.
Megalodon,	…	••	…	•	•	••	•••	?
Cardinia,	…	••	…	•	•	•	•	?
Cardita,	…	••	••		••	••	••	Various depths; mostly littoral.
Cypricardia,	?	?	?			•	••	Sands; and on reefs.
Hippopodium,	…		?					?
Isocardia,	•	•	•	…	•			Various depths; in mud.
Cardiomorpha,	…	•	•		•			?
Pleurorhynchus,	•	••				•	•	?
Cardium,	•	••		•	•	•	•	Littoral, to considerable depths.
Hippagus,	…	•						?
Cardiola,	…	…	•			•	•	?
Tridacna,	…	•	…	•				Shallows, and littoral, on rocks and reefs.
Opis,	…	…		…	••			?
Corbis,	…	…	•	…	…	••	•••	Littoral, or shallows?
Lucina,	•?	…	•	•	…	•	•	Littoral, and moderate depths; some species deep sea.
Diplodonta,	…	•	•	•		•	•	Various depths.
Cyclas,	…	…	•	•	•			Fresh-water.
Cyrena,	…	…	•	…	••		•	Do.
Kellia,	…	…	•	…	•	••	••	Littoral, to very deep.
Lepton,	…	…	•	…	•	•		Shallows, and moderate depths.
Trigonia,	…	…	•	…	•	•	•	Moderate depths.
Nucula,	•	•	••	…	•	•	•	All depths. The deepest living genus known, of this order.
Limopsis,	…	•	•	•	•	•	•	?
Pectunculus,	?	?	•	••	•	••	•	Moderate depths.
Arca,	•	•	•	•	••	…	•	From the water's edge, to the greatest depths.
Mytilus,	•	•	•	•	•	•	•	Littoral, and deep sea.
Lithodomus,	…	•	•	•	•	•	••	Littoral; boring.
Edmondia,	•	…	•	••	••	•		?
Myoconcha,	…	••	•	•	•	•	•	?
Sanguinolites,	••	••	•	•	•	•	•••	?
Pinna,	…	••	•			•	•	Sub-littoral, and at considerable depths.
Dreissena,	…	•	•	•		•	•	Fresh-water.
Chama,	…	…	•	•				On rocks; littoral, and shallows.
Diceras,	…	…	…	…	•			?
Etheria,	…	…	…	•	•	•	•	Fresh-water.
Avicula,	•	•	…	•	•	••	•	Shallows, to considerable depths.
Pterinea,	•	•	•	•	•	•	•	?
Posidonia,	•	•		•	…			?
Crenatula,	…	…	•		•	…	•	Marine sponges, and on corals.
Perna,	…	…	•			•	•	?
Gervillia,	…	•?	•	…	…			?
Inoceramus,	•	•	••	•	•	…		?
Vulsella,	…	…	•	•		•	•	?
Lima,	…	…	…	••		•	•	From shallows to very great depths.
Pecten,	…	•	••	•	•			Do. do.
Hinnites,	…	…	••	••	•	…		Do. do. ?
Plicatula,	…	…	…	••	••	•	•	Moderate depths.
Spondylus,	…	•?	•	•	•	••	•••	Shallows, and moderate depths.
Astrea,	…	…	•	•	•	•	•	Various depths.
Gryphæa,	…	…	•	•	•	•	•	?
Placuna,	…	…	•	•	••	••	•	Sandy bottom; shallow?
Anomia,	…	…	…	•?	•	••	•	Various depths, and littoral.
PALLIOBRANCHIATA.								
Caprotina,	…	…	•	•	•	•	•	?
Caprina,	…	…	…	•				?
Ichthyosarcolites,	…	…	…	•				?
Hippurites,	…	…	…	•				?
Radiolites,	…	…	…	•				?
Crania,	•	•	•	•				Usually very deep sea.
Orbicula,	•	•	•	•	?			Shallows, and deep sea.
Obolus,	…	•	•	•	?	?	•	?
Calceola,		•					•	?
Thecidea,	…	…						Deep sea.
Productus,	•	•••	•	••	…			?
Chonetes,	•	••				•	•	?
Leptæna,	••	•						?
Orthis,	••	•	•					Probably (by analogy) deep sea.
Spirifer,	•	•••	•					?
Pentamerus,	•							Probably deep water.
Strigocephalus	…	••						Do.
Terebratula,	••	•••	••	••	•	•	•	Littoral to great depths. The majority of species very deep sea.
Lingula,	•••	•	•	•	•	•	•	Shallows, and moderate depths; probably anciently in great depths.

TUNICATA.

Evidences of the existence of this important order of Molluscs in the fossil state are very obscure, as might be expected when the unpreservable nature of the living forms of the order is considered. The Silurian genus, *Ischadites*, was supposed to be possibly a form of Tunicated Molluscs, but the evidence is by no means clear, and many of the characters of those remarkable fossils would rather indicate their relationship with the *Cystideæ* among the Echinodermata, than with any division of Mollusca.

CRUSTACEA.

The preservable nature of the integuments, and the aquatic habits of the majority of the species of Crustacea, render this class of articulate animals peculiarly interesting to the palæontologist. Remains of Crustacea occur in formations of all epochs, but the majority of the palæozoic species are very different from any existing forms, and belonging, as they do, to the division called *Paleadae* or Trilobites, are peculiar to, and highly characteristic of, palæozoic fossiliferous rocks.

Trilobites were first made known by British observers, and first discovered in South Wales. The writings of Edward Lhwyd, published about the middle of last century, contain the earliest papers on these interesting fossils. Those he described were from Silurian rocks. The following are the principal genera recorded as found in Britain according to the nomenclature of Burmeister.

Trinucleus.—Four or five species, mostly lower Silurian.

Ampyx.—Three or four species.

Ogygia.—3 or 4 species, lower Silurian. *Ogygia Buchii* is highly characteristic of the Llandeilo flags.

Paradoxides.

Olenus.—(With *Remopleurides.*) *O. micrurus* is our oldest British trilobite.

Cheirurus.

Agnostus.—Three or more species.

Lichas.

Harpes.—The species of this genus are from the Silurians of Ireland.

Calymene.—The *Calymene Blumenbachii* is the well-known Dudley Trilobite, and has a great vertical extension in the Silurian system, as well as a very wide geographical distribution. There are several other British species.

Homalonotus.—A genus highly characteristic of upper Silurian rocks, and ranging into the Devonian.

Sphærexochus.

Cybele.—Several species.

Phacops.—Several species.

Proetus.—Several species. The genus *Forbesia* of M'Coy falls here.

Illaenus and *Bumastus.*—Several species; five of the former section usually lower Silurian, and among the oldest of Trilobites.

Asaphus, several species.

The other recorded Crustaceans found in our Silurian rocks are Ostrapoda of the genera *Cythere* and *Beyrichia.* The curious genus *Pterygotus* is crustacean.

In our Devonian strata several Trilobites occur. *Brontes flabellifer* is one of the most remarkable and characteristic. *Harpes macrocephalus* is another striking form. Several species of *Phacops* also occur. Some remarkable Crustaceans are found in the old red sandstone.

In our carboniferous rocks the allied genera, *Griffithides* and *Phillipsia* include all the Trilobites of their epoch. They occur in the mountain limestone. Numerous Crustaceans of other tribes however, make up for the paucity of Trilobites. The genera *Dithyrocaris, Entomoconchus, Cytherina, Daphnia, Bairdia*, and *Cythere* (the last, including a long array of species), are enumerated by M'Coy as occurring in the mountain limestone of Ireland. The genus *Limulus* occurs in the coal measures of Coalbrook Dale, and *Eurypterus* in the Scottish coal measures. Several species of Cypris occur in the English coal measures. An *Apus* is recorded by Mr. Prestwich among Coalbrook Dale fossils.

Few Crustaceans are recorded from the British oolitic strata. Such as are, chiefly belong to the *Macroura.* They include the *Coleia antiqua* of Broderip, and the *Glyphæa liassina*, from the lias of Lyme, and several species referred to *Astacus* by Phillips, from oolitic beds in Yorkshire. In the Purbeck and Wealden species of *Cypris* occur in greater plenty, also Isopodous Crustaceans and *Estheria.*

Many Crustacea have been found in our cretaceous rocks. Some of the lower beds of the lower green sand, in the Isle of Wight, abound in remains of *Astaci*, often in tolerable preservation. *Astaci* also occur in the upper green sand, and in the chalk. An *Eryon* has been found in the chalk at Staining, and an *Etyœa* in the gault. *Pagurus Faujasi*, and *Scyllarus Mantelli*, are also British chalk Crustaceans. 26 forms of *Entomostraca* are described as British Cretaceous species by Mr. Rupert Jones.

The London Clay of Sheppey abounds in Crustacean remains. Among these are both Macrourous and Brachyurous species; but very few of the forms found have as yet been described. The recorded species are referred to *Cancer, Inachus*, and *Dromia.* [illegible] *Cytherina* [illegible] is a London clay fossil.

In our newer tertiaries such remains of Crustacea as have occurred belong to existing genera, and mostly to existing British species. Among the latter are the *Ebalia Bryerii, Pagurus Bernhardus*, and *Cancer pagurus.*

Many more fossil Crustaceans are recorded from foreign than from British strata. *Brachyura* are recorded from cretaceous strata in Europe and America, and many species have been found in tertiaries of Europe and of India. A few Anamourous Decapods have been found in the tertiaries of all ages. The Macrourous genus *Pemphix*, is only known in the muschelkalk. The lithographic slates of Germany contain numerous forms of *Macroura.* Of *Stomapoda*, a species of Squilla is recorded from the slates of Monte Bolca. The Amphipodous genus *Typhis*, is represented in the tertiaries of North America. Terrestrial *Isopoda* are preserved in the amber of Northern Germany. Several Isopodous genera occur in the German lithographic slates. Trilobites occur abundantly in foreign palæozoic rocks in both hemispheres; and many generic forms are found of which we have no British examples. Cyproid Crustaceans occur in foreign beds of various ages. *Xiphosura* are found in the muschelkalk and jurassic beds of Germany. Bronn enumerated 894 species of fossil crustacea as recorded in 1849.

CIRRHIPEDA.

The most ancient of our Cirrhipeds are species of *Pollicipes*, recorded by Morris and by Buckman from oolitic strata. This genus is represented also in the lower green sand, the gault, the chalk, and the London clay. The *Loricula pulchella* of George Sowerby is a remarkable pedunculated Cirrhiped from the white chalk. *Balani* occur in the London clay, the red and coralline crag, and pleistocene beds. All the newer tertiary species appear to be identical with existing forms. The genera *Acasta, Adna*, and *Scalpellum*, all occur in the coralline crag, and *Clitia* and *Coronula* have been found in the red crag. Mr. Darwin's monograph should be consulted on this subject.

Few Cirrhipeds have occurred in foreign localities. Roemer records a number of *Pollicipes* from the cretaceous beds of Northern Germany; and Phillippi enumerated several Cirrhipeds, both pedunculated and sessile, from Mediterranean tertiaries. Species of *Balanus* have been found in tertiary beds of North America and of India.

INSECTA.

The remains of insects, like those of other inhabitants of the dry land and air, are comparatively rare in the fossil state, their preservation in sedimentary deposits being mostly accidental. Such as are found chiefly occur in fresh-water formations. The first traces of insects occur in the coal measures of Coalbrook Dale. Of these, two have been described by Dr. Buckland as species of Curculioides, a genus founded for them on account of their resemblance to weevils, though Professor Pictet doubts their true relationship to this tribe. With them the wing of a Neuropterous insect has been taken. In the lias of Gloucestershire numerous remains of insects have been discovered, especially by Mr. Brodie, who has published an interesting account of them in his "History of British Fossil Insects." They belong to ten species, members of the orders Coleoptera, Neuroptera, Orthoptera, and Diptera. In the Stonesfield slate, Mr. Brodie has found a *Prionus* and a *Coccinella.* The same gentleman has discovered no fewer than twenty species of insects in the Purbecks, representatives of many orders and tribes. None have, as yet, been observed in British deposits of the cretaceous epoch; nor have the British eocene tertiaries, not even those of fresh-water origin, yielded any. The red and coralline crags are equally barren in insects. In the fresh-water pliocene of Munderley, Mr. Lyell has found remains of the genera *Copris, Donacia*, and *Harpalus.* Remains of insects are frequent in peat.

Abroad, the most ancient fossils of this order have been found in jurassic beds, especially in the lithographic slates of Bavaria.[1] Traces of insects have been observed in the cretaceous slates of Glaris, and Elytra of Coleoptera have been found in the chalk-marl of Normandy. Our knowledge of the insect fauna of the tertiary epoch is chiefly derived from some continental beds, especially those of Aix in Provence, the marls of Œningen, and the lignites of the neighbourhood of Bonn.[2] By far the most prolific source of fossil insects is, however, the amber of the Baltic shores, a fossil resin, the produce of the *Pinus Succinifer*, an extinct tree of the eocene epoch. In this resin, when fresh, insects and even small reptiles became entangled, and thus have been preserved in the most perfect condition. It is evident that from such materials, since they are abundant, we acquire good data for judging of the state of life in central Europe during the early stage of the tertiary epoch. The researches of Dr. Berendt and Professor Pictet have made known to us the results. The conclusions of the latter naturalist, respecting Neuropterous insects found in amber, will serve to show the light they throw upon the terrestrial, or rather aerial eocene fauna. He states, that they are all either species very near to, but not identical with, living Prussian forms—or forms (extinct) characteristic of inter-tropical and mediterranean climates—or members of extra-European genera, some even American—or members of entirely new genera, the last being comparatively few. Professor Pictet has remarked, respecting fossil insects generally, that though the remains are few, there is every reason to think that this class was numerously represented in ancient epochs, especially during the tertiary times; and he does not doubt their abundance during more ancient geological periods, although their destruction appears to have been almost total. The weakness of their integuments, and the minuteness of the majority of the tribe, would go far to account for the rarity of their preservation. The researches of Heer have added greatly to our knowledge of fossil insects of the Tertiary epoch.

ANNELIDA.

The majority of true worms being soft-bodied animals, are not very likely to be preservable in a fossil state, consequently we find but few traces of this important class of articulate animals. Many of them, however, when trailing over the soft sands and muds, on which they usually live, leave impressions of their course sufficiently distinct to mark the order, and, in some cases, the genus to which the creature belongs. Similar impressions to those made by existing worms upon the sea-shore, have been found in the sandstone and shales of various ancient formations, and we have every reason to believe that they were made by similar creatures. In the oldest fossiliferous beds of the Silurian system in Wales, such impressions occur. The names *Nereites* and *Myrianites* have been given to them. Several varieties have been distinguished. With them are found impressions which have been referred to the trails of Abranchous Annelides; to these the name of *Nemertites* has been given. Similar trails occur among oolitic rocks, and, when searched for more carefully, will probably be found very generally in rocks of all ages.

The remains of Annelides constructing shelly tubes occur in rocks of all ages. They have been distinguished into genera and species; but this determination, judging from recent researches upon the existing forms of tubicolous Annelides, will probably rest for ever uncertain and empirical. We now know that among the Serpulidæ very different animals inhabit similar and undistinguishable shells, the difference being often of generic importance. Arguing from analogy, then, it will be quite impossible to judge of the palæontological connection of two or more formations, by the presence in them of forms apparently identical of shells of this order. But, though useless in a chronological point of view, they may be of importance in determining the circumstances of depth and conditions under which a stratum was deposited, for we find that many of the existing forms afford very certain indications of depth.

Fossils referrible to the genus *Serpula*, using the word in its widest and Linnæan sense, occur in the British Silurians (*Spirorbis Lewisii*); in the carboniferous limestones (many species, especially in Ireland); in the various strata of the oolitic period (23 British species recorded); in the cretaceous rocks (29 British species); in the eocene tertiaries (8 species); and in the newer tertiaries, where the forms are such as to indicate every probability of their being identical with existing species.

In searching for fossil Serpulæ, the operculum should be carefully looked for, since it affords the best indication of the generic relations of the shell; but few opercula of fossil Serpulæ have as yet been described.

Nearly allied to Serpulæ is the genus *Ditrupa*, a group of shells so closely resembling *Dentalia*, that until the animal constructing them was made known by Berkeley, they were supposed to belong to the Mollusca Gasteropoda. By some mistake they have lately been enumerated in geological works and catalogues as Pteropodous Mollusca. Well-marked species of *Ditrupa* occur in the British tertiaries. The *Ditrupa planum* is remarkable as the first fossil which occurs in abundance in our eocene beds. It is probable that the palæozoic fossils to which the generic appellations of *Serpulites* and *Entobia* have been applied, are the shells of animals very closely allied to the *Ditrupæ.* The *Serpulites longissimus* is a very curious and characteristic Silurian fossil.

Numerous testaceous Annelides, not hitherto observed in British formations, are described in the works of foreign authors. Devonian Serpulidæ have been figured by Goldfuss: also muschelkalk species. The same author gives forty-three liassic and jurassic species from Germany. De Koninck has figured several forms of Spirorbis from the carboniferous rocks of Belgium. Above fifty forms of cretaceous Serpulidæ have been observed in Germany and France. Fossil Ditrupæ occur in the green sand rocks of Southern India. Many Continental and American tertiary Serpulidæ are figured.

ECHINODERMATA.

The following table exhibits the comparative development of the orders of Echinoderms during the several geological epochs and the present time within the area of the British Islands. The absence of fossils of the two highest orders during former epochs is not to be attributed to absence of animals of those types, but rather to their unpreservable nature. The great development of the Echinidæ during the central epochs is a very important fact clearly made out. The undeveloped condition of the *Asteriadæ* and *Ophiuridæ* during geological epochs, as contrasted with the present, may depend only on their comparatively unpreservable nature, and not on absence. The great development of the Cystideæ during the earliest periods is unmistakable. So also is the far greater importance of the Crinoideæ anciently than now. As a whole, the Echinoderms afford decided indications of higher temperature within our area during the secondary epochs, and of the diminution of that temperature during the tertiaries, till it reached a minimum in the pleistocene period and rose again with our own. The indications they afford of the climate of the palæozoic epoch are not so clear.

Orders of Echinodermata.	Lower Palæozoic.	Upper Palæozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Present Epoch.
Sipunculidæ,	…	…	…	…	…	…	•••
Holothuriadæ,	…	…	…	…	…	…	•••
Echinidæ,	?	•	•••	••	•	•	••
Asteriadæ,	•	•	•	••	•	?	•••
Ophiuridæ,	•		•	•	•	?	•••
Cystideæ,	•••	•					
Crinoideæ,	••	•••	••	•	•	•	•

Although *Holothuriadæ* have not been found in a fossil state, it is not improbable that the peculiar calcareous specula which stud their skins may yet be found among microscopic remains.

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[1] See the papers of M. Germar, in the Nov. Art. Acad. Nat. Cur. t. xix.; and the fifth part of Count Munster's Beiträge.

[2] See Murchison, in Jameson's Journal, 1829, and the 3d vol. of the Geological Transactions, 2d series; also the writings of Marcel de Serres, Germar, and Scherer.

Sea urchins abound in the fossil state, especially in cretaceous and oolitic strata. In Britain they first distinctly appear in the lias. They become very abundant in the oolites. Many of the oolitic forms are members of still-existing genera, but more belong to extinct groups. *Cidaris* and *Echinus*, genera still represented in the British seas, had many members within our area during the lower secondary epoch. The tropical genus *Clypeus* was also present. *Diadema*, *Pygaster*, *Dysaster*, *Discoidea*, and *Nucleolites*, are among the British oolitic urchins. During the cretaceous period new genera appeared in our seas. An entire group—that of which *Salenia* is the type—appeared and vanished. *Cidaris* assumed many and varied forms. *Ananchites* and *Galerites* were especially characteristic of the higher cretaceous beds. Many Spatangaceæ, especially members of the genera *Spatangus*, *Brissus*, and *Holaster*, were common. *Carotomus*, *Cassidulus*, and *Nucleolites*, had well-marked representatives. In the British eocene strata few *Echinidæ* have been noted. Those recorded belong to existing genera; which is also the case with the miocene and pliocene species.

The researches of Agassiz have vastly extended our knowledge of the fossil Echinidæ. He has established numerous well-marked groups, many of them of great geological importance, in consequence of their very definite relations with the strata in which they occur. The genera, as defined by the great Swiss naturalist, are, however, far from equal in value, and many of the subordinate divisions can be looked upon only as subgeneric sections at best. Of a great number of them we have no British representatives; indeed, many continental strata, of various formations, are much richer in Echinidæ than any in our own country. The following table will show the distribution in time of the principal genera of *Echinidæ*, British and foreign. The first series of names are those of genera confined to the formations under which they follow in order. The series lower down, placed under brackets, are common to two or more formations, according as the brackets indicate by their extent. Genera, represented by living as well as fossil species, are marked by an asterisk:—

TERTIARY.	CRETACEOUS.	OOLITIC.
* *Clypeaster.* * *Most Scutellidæ.* * *Echinometra.* * *Temnopleurus.*	*Cardiaster.* *Ananchites.* *Galerites.* *Caratomus.* *Catopygus.* *Amblypygus.* *Conoclypeus.* *Echinopsis.* *Cyphosoma.* *Saleniadæ.*	*Pedina.* *Acrocidaris.* *Acrosalenia.* *Glypticus.* *Acropeltis.*
Cassidulus. *Pygorhynchus.* *Echinolampas.* * *Echinocyamus.* * *Amphidetus.* * *Spatangus.* * *Brissus.*	*Holaster.* *Dysaster.* *Discoidea.* *Pygurus.* *Diadema.* *Tetragramma.* *Hemicidaris.*	
	* *Clypeus.* *Nucleolites.* * *Cidaris.* * *Echinus.*	

From the preceding table it will be at once observed that the genera which exist in both a living and fossil state, are either such as range through several epochs, always including the tertiary, or such as commenced their existence in the epochs nearest our own time. Thus, with the exception of the genera which are common to the whole of the secondary, the tertiary, and the present epochs, all the types of the oolitic epoch are extinct so are all those common to the oolitic and cretaceous strata, but not ranging higher. So are all those peculiar to cretaceous strata. Among the genera common to the cretaceous and tertiary epochs, however, there are several which are common to those times and the present; and all the tertiary genera which are not found lower down in the geological series, have representatives among living animals.

The absence of true Echinidæ previous to the secondary epoch is a very remarkable fact. It is possible that representatives of this group may yet be discovered in palæozoic strata, but we can hardly expect to find them in such variety as to invalidate the conclusion that they are conspicuously characteristic of secondary, tertiary, and existing times. We find their forms and many of their characters closely imitated, however, by members of the following group; indeed, so closely that many naturalists still regard the fossils which constitute the genera *Archæocidaris* and *Palæchinus* as Echinidæ.

Until lately very few *Asteriadæ* were known in a fossil state. Now about thirty British species are known, and eleven of *Ophiuridæ*. In the Silurian rocks of Wales, Ireland, and the north of England, we find several species of star-fishes, apparently referrible to the existing genus *Uraster*. With them Professor Sedgwick has discovered the *Protaster*, the only known fossil representative of the family of Euryalidæ. *Ophiuræ* also occur. In the oolites several star-fishes are found. The *Ophioderma Egertoni* is a well-known marlstone species. Other forms occur, as well as of *Ophiura* proper, *Amphiura*, and *Aspidura*, in oolitic strata. Several species of Asterias are found in beds of the same epoch. In cretaceous epochs numerous star-fishes are found. The genus *Comtonia*, or *Stellaster*, is characteristic of the green sands, *Goniaster* of the chalks. The common tropical genus *Oreaster* has several representatives in our chalk. *Ophiuræ* also occur.

In the London clay many remains of star-fishes occur, referrible to the genus *Asterias* proper. An *Ophiura* has been discovered in the same formation by Mr. Wetherall. Our newer tertiary Asteriadæ have not been made out.

Abroad, remains of star fishes have been found in the Silurians of North America, in the muschelkalk, lias, and oolites of Germany, in the cretaceous strata of Germany, Sweden, France, and Southern India.

The CRINOIDEÆ are among the most interesting and curious of fossil invertebrata. This important tribe had its greatest development during the palæozoic and secondary epochs, diminishing materially towards the close of the latter, and becoming scant and scarce during the tertiary and historical epochs. They commence their existence with the earliest sedimentary deposits, and arrive at their maximum of development before the close of the palæozoic periods. In the lower Silurians they are fragmentary, but common; in the upper beds of that formation many fine species occur, often well preserved in limestones. *Actinocrinus*, *Cyathocrinus*, *Dimerocrinus*, *Rhodocrinus*, *Eugeniocrinus*, *Taxocrinus*, *Trochocrinus*, and *Hypanthocrinus*, are British Silurian genera. During the Devonian epoch we find the genera *Cyathocrinus* and *Platycrinus*, *Taxocrinus* and *Adelocrinus*. The limestones of the carboniferous period abound in Crinoideæ. Numerous species of *Actinocrinus*, *Platycrinus*, *Cyathocrinus*, *Poteriocrinus*, occur, with others of the genera *Rhodocrinus*, *Symbathocrinus*, *Gilbertsocrinus*, *Taxocrinus*, &c. The commencement of the secondary period is marked by abundance of *Pentacrini*, indicative of a new series of Crinoidal forms. At Lyme Regis, where they have been found in great numbers, they occur associated with fossil-wood in such a manner that there can be little doubt that they lived attached to floating masses of wood, probably in shallows. Higher up, among the oolitic strata, we find the curious genus *Apiocrinus* (the Pear Encrinite), which appears to have lived attached to ancient banks of coral. During the cretaceous epoch the free Crinoids begin to appear, and *Comatulæ* seem to have been not uncommon. The genus *Marsupites* is a remarkable form of this group, and disappears before the commencement of the tertiaries. The last of the fossil Pentacrinites appear in eocene strata, but as the genus still lives it is probable that intermediate species will be found. *Comatula* existed during all the tertiary epochs. In Britain, however, no trace of it has been found in pleistocene strata. The supposed genera of Echinidæ, *Ganymeda* of Gray, and *Glenotremites* of Goldfuss, are only the cups of *Comatulæ*.

It may be noted generally respecting fossil Crinoids: 1*st*, That all the genera of the family *Actinocrinidæ*) including such as have cups composed of thin and slightly articulated pieces, and having much-divided arms), as *Rhodocrinus*, *Actinocrinus*, *Gilbertsocrinus*, *Melocrinus*, *Scyphocrinus*, *Cyathocrinus*, *Platycrinus*, *Dimerocrinus*, *Hypanthocrinus*, &c., are confined to palæozoic strata. 2*d*, That all the genera of the family *Poteriocrinidæ* (composed of such as have their cups made up of large and strong segments, but in general aspect closely resembling the members of the first tribe), as *Poteriocrinus*, *Isocrinus*, and *Symbathocrinus*, are palæozoic. 3*d*, That the genera of the family *Pentacrinidæ* (characterized by the strongly articulated segments of their cups and head of the column, and by the side arms of the latter) range from the triassic epoch to our own times, having their maximum during the oolitic epoch. 4*th*, That the genera of the family *Apiocrinidæ* (characterized by the pear-shaped and articulated summits of the stem and cup, and the naked column), as *Apiocrinus*, *Guettardocrinus*, *Millericrinus*. *Encrinus*, and *Eugeniocrinus*, are secondary, and for the most part oolitic. *Encrinus* is a genus not found in British strata, and characteristic of the trias (muschelkalk). It is the well-known stone lily, or lily encrinite of collections. The genus *Bourgueticrinus* of D'Orbigny, of which two species are, however, from the chalk, is an exception to the above rule, if the remains of a Crinoid, found preserved in the recent blank of the Antilles, be rightly referred to it. 5*th*, The free Crinoids, *Comatulidæ*, appear to have ranged from the oolitic period to the present time; for in the lithographic slates of Bavaria we find several remains of animals closely allied to *Comatulæ*. This family appears to have attained its greatest development during our own epoch, and as certain living species are known to pass through stages exactly comparable to the adult state of the stalked Crinoid, we must regard the *Comatulidæ* as the most advanced of Crinoidal forms.

The CYSTIDEÆ are singular Echinodermatous fossils, closely allied to the Crinoids, and appearing to form a great and rapidly metamorphosing group, diverging within itself, and conducting from the Crinoids to the Echinidæ and Asteriadæ by a metamorphosis at first apparently retrograde, and repeating the rudimentary forms of the Crinoids themselves. They are essentially palæozoic. Little has been known of them as British fossils until very lately. In the lower Silurians we find four species of *Sphæronites*, three of *Caryocystites*, one of a genus allied to *Cryptocrinites*, and several of *Hemicosmites*. In the upper Silurian, three species of *Sycocystites* occur, and three of *Pseudocrinites*. In carboniferous rocks the curious genera *Palæchinus* and *Archæocidaris* represent the Cystideæ, and most probably also the *Pentremites*.

Cystideans occur in the Silurians of Russia, Scandinavia, and North America.

ZOOPHYTA.

When we consider what an important part corals play in the formation of new land, and in the contribution of new material for the sea-bed, it is evident that the study of fossil Zoophytes must be of no small geological importance. Such tribes as have calcareous skeletons are especially valuable to the palæontologist, from the perfection with which their framework may be preserved in the fossil state. Of the soft kind—and they form no inconsiderable part of this class of animals—we cannot expect to find many traces. Numerous Actineæ and allied forms, and millions of naked hydroid Polypes might have lived in any or in all ages of the ancient world, yet have left "not a wreck behind." Hence conclusions drawn from geological researches of the comparative ancient and present development of the class must be fallacious and valueless. But the abundance of zoophytic remains contained in many ancient rocks, affords good data for judging of the relations of the earlier preservable forms with those now living belonging to the same tribes. And from these we learn that, on the whole, there has been little, if any change, in the plan of zoophytic organization since the beginning of geological time; that, whilst some genera have passed away, and new ones have taken their places, the earlier forms were as perfect as their successors. Indeed, among the very earliest, the most perfect forms of Zoophytes play as important a part as the most rudimentary. Most of the zoophytic genera are remarkable for their great duration in time; and this applies also to a great many species, both during palæozoic and tertiary epochs.

In speaking of Zoophytes in connection with geology, it is convenient to use the term so as to include both Zoophytes proper and Bryozoa, although the latter order rightly take their place among Mollusca. Yet there "polypidoms," to misapply the word, are so similar to those of true Zoophytes, that it is almost impossible to draw a line between them when in the fossil state; and even in the living it is at times very difficult to do so, however dissimilar the organization of the creatures might be by which they were constructed.

In the Silurian rocks of Britain we find a considerable assemblage of Zoophytes, both Bryozoa and true Polypes. The somewhat anomalous genus *Favosites*, and its ally *Chætetes*, are among the first that appear, and are found very low down among the lower Silurians. *Petraia* or *Turbinolopsis* (*bina*), *Catenipora* and *Aulopora* are also very early forms. The Catenipora escharoides have a very great range, extending into the Devonian rocks abroad. *Favosites Gothlandica* and *Favosites fibrosa* have an equal distribution. So also has the *Porites pyriformis*, and perhaps the *Stromatopora concentrica*. *Syringopora catenata*, an upper Silurian fossil, ranges into the carboniferous limestone. Species of *Astræa*, *Porites*, *Turbinolia*, *Fungia*, *Millepora*, *Gorgonia*, *Eschara*, *Flustra*, *Pustulipora*, and *Retepora*, show a certain relation between the Silurian fauna and that of the existing period; whilst *Ptylodictyon*, *Intricaria*, *Strombodes*. *Catenipora*, *Syringopora*, and *Petraia*, give marked and peculiar features to the Silurian zoophytic fauna, though closely allied with that of the upper palæozoic rocks. In the upper Silurians, corals, especially the larger kind, are much more abundant than in the lower, especially in the Wenlock limestone, wherein we find a great variety of forms for the most part exquisitely preserved.

In Devonian strata we find, as already noticed, many Silurian species. Many, however, have disappeared, and become replaced by others. The genus *Astrea* becomes more developed, and *Fenestellæ* are numerous and characteristic. In the limestones of the carboniferous system numerous Zoophytes occur, often forming considerable masses. The species of *Cladacora*, *Cyathophyllum*, *Lithodendron*, and *Lithostration* or *Columnaria*, especially play a conspicuous part. Numerous minute corals are also preserved in great beauty in the mountain limestones of the north of England, and many parts of Ireland.[1] Species of *Fenestella* occur in the Magnesian limestone of Durham; and one of these, the *Fenestella retiformis*, is common to that rock and the carboniferous limestone. Eleven Permian Zoophytes are enumerated by King.

Taken as a whole, the Palæozoic Zoophytes present a marked contrast with those of secondary and tertiary epochs, though so many of the genera are common to all. Among the Silurian Zoophytes are some forms which are yet very uncertainly placed, as the genus *Graptolites*, hitherto confined to Silurian rocks, and very characteristic of that formation. The Graptolites appear to have been Sertularian Polypes, but some of the forms have a singular resemblance to some of the varieties of sea-pens, so that it is more than probable that several generic groups have been confounded under one name.

During the oolitic epoch there was a great development of Zoophytes in our seas, though not during its earlier stage; for in the lias polypidoms are rare. In some of the higher beds great assemblages of corals occur. The coral rag is an example. *Astræa* and *Turbinoliæ* are especially abundant. The species are often very similar in habit to existing tropical and Indian Ocean forms. They are associated with numerous Bryozoa—many of them members of existing genera. It is probable that many more species of Zoophytes than have been described will be made known from oolitic strata.

The Zoophytes of our Cretaceous rocks have been examined by Milne Edwards and Haime, and by Lonsdale. They are numerous and most interesting, for we find not a few which are very closely allied to existing deep-sea species, especially about the junction of the upper and lower chalk. In the upper green sand corals are common, and several Helianthoid genera occurs. Bryozoa are more abundant than in previous formations.

Twenty-eight eocene Zoophytes have as yet been made known. These are described by Milne Edwards and Haime. In foreign eocene strata, Zoophytes are numerous and varied, as may be seen by the following tables.

From the coralline crag no fewer than fifty-seven species of Zoophytes have been recorded by Mr. Searles Wood. Of these, eighteen or nineteen are existing British forms. They are associated with Polyparia and Bryozoa of a more southern character, including species of *Balanophyllia*, *Cladacora*, *Fascicularia*, *Theonoa*, *Hornera*, *Lunulites*, *Fungia*, &c., of which we have now no representatives in our seas. In the red crag only twenty-five species have been observed, and of these fourteen are existing British forms. In beds of the pleistocene epoch still fewer have been found, and all are existing species of northern origin.

TABLES showing the distribution in time of the best-marked genera (whether British or Foreign) of fossil Zoophytes. In the last column such as are still represented are indicated. When two or more asterisks occur, a great development of the genus is indicated. The nomenclature, pending researches now in progress, can be regarded only as provisional, and as that most commonly used in geological works.

TABLE I.

BRYOZOA.	Older Palæozoic.	Newer Palæozoic.	Older Secondary.	Newer Secondary.	Older Tertiaries.	Newer Tertiaries.	Present Epoch.
Eschara	*	*	*	*	**	*	*
Escharina	*	···	···	*			
Lepralia	···	···	···	···	···	**	***
Melecortina	···	···	···	···	···		
Tilisia	···	···	*				
Ptylodictyon	*						
Membranipora	···	···	···	···	···	*	**
Flustra	*	···	···	*	*	*	**
Discopora	*	*	···	*	*		*
Ocellaria	···	···	···	*			
Cellepora	···	*	*	*	*	**	***
Marginaria	···	···	···	*			
Aspendesia	···	···	*				
Acicularia	···	···	···	···	*		
Cellaria	···	*	···	···	?	*	*
Glauconome	*	*	···	···			
Intricaria	*						
Dactylopora	···	···	···	···	*		
Polytripa	···	···	···	···	*		
Vaginopora	···	···	···	···	*		
Conulina	···	···	*				
Verticilopora	···	···	···	*	···	···	*
Tubulipora	···	*	···	*	*	*	**
Crisia	···	···	···	···	···	*	**
Hippothoa	···	···	*	···	···	*	*
Alecto	···	*	*	*	?	*	*
Filicella	···	···	···	···	···	*	*
Hornera	*	*	···	*	*	*	*
Idmonea	···	···	*	*	*	*	*
Pustulipora	*	*	*	*	*		
Diastopora	*	···	*	*			
Cricopora	···	···	*	*			
Retepora	*	*	*	*	*	*	*
Distichopora	···	···	···	···	*		
Ceriopora	*	*	**		*		
Thalamipora	···	···	···	*			
Chrysapora	···	*	**	*			
Myriapora	···	···	···	*	*	···	*
Orbitolites	···	···	···	*	*	*	*
Lunulites	···	···	···				

TABLE II.

Asteroid and Helianthoid Polypes.	Lower Palæozoic.	Upper Palæozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Recent.
Alcyonium,	···	*	?	*	···	···	*
Pennatula,	···	···	···	···	*?	*?	*
Gorgonia,	*	*	*	···	*	···	*
Fenestella,	*	*					
Alveolites	**	*	*	*			
Pelagia,	···	···	*	*			
Seriatopora,	···	···	···	*			
Millepora,	*	*	*	*	*	*	
Theonoa,	···	···	*	···	···	*	
Stromatopora,	*	*					
Favosites,	**	**	*	*	*		
Chætetes,	*	*					
Isis,	···	*	···	···	···	*	*
Oculina,	···	···	*	···	*	*	*
Explanaria,	···	···	*	···	*	*	
Cladacora,	···	*	*	*	*	*	
Columnaria,	···	*	*				
Strombodes,	*	*					
Cyathophyllum,	*	*	*				
Michelinia,	···	*					
Mortieria,	···	*					
Cystiphyllum,	*	*					
Caryophyllia,	*	*	*		*	*	*
Astrea,	*	*	**	*	*		*
Thamnasteria,	···	···	*				
Porites,	*	*	*	*	*	*	*
Fungia,	*	*	*	*	*	*	*
Turbinolia,	*	*	*	*	**	*	*
Petraia,	*	**		···			
Cyathina,	···	*?	*?	···	···		*
Aulopora,	**	*	*	*			
Meandrina,	···	···	*	*		*	
Pavonia,	···	*	*				
Agaricia,	···	*	*	···	*	···	*
Monticularia,	*	···	···	···	···	···	*
Heteropora,	···	···	*	*			
Madrepora,	···	···	*	···	*	*	*
Catenipora,	*						
Syringopora,	**	*					

AMORPHOZOA.

The sponges may be regarded as the lowest among animal forms. They are compound beings; masses of animals of the simplest structure, each individual of the nature of the microscopic *Proteus*, which is a simple form in the amorphozoic group. The term *Amorphozoa* is, however, very inappropriate, when applied to such exquisitely symmetrical creatures, or combinations of creatures, as the *Foraminifera*, members of this group, though long, from the resemblance of their shells to Nautili, supposed to be Mollusca of the highest class.

The Sponges, properly so called, are but indistinctly indicated in the oldest sedimentary strata. *Cnemidium tenue* (Lonsdale) is a Silurian fossil supposed to belong to this tribe. *Manon cribrosum*, and *Scyphia turbinata*, are British Devonian fossils. Traces of Sponges occur in the carboniferous limestone of Ireland. They become frequent and well-marked in oolitic strata of marine origin, often closely simulating existing forms. In cretaceous rocks they are still more abundant, especially in the upper green sand. Thirty-nine British species are named. Most of these appear to have been structurally allied to existing genera; but the supposed Sponges, called *Ventriculites*, from the chalk, have been lately shown by Mr. Toulmin Smith to present peculiarities of structure very distinct from any organization yet discovered among these bodies.[1] The researches of Mr. Bowerbank have made known the microscopic structure of numerous Sponges included in chalk flints, and have shown that, in the majority, the organization is very similar to that presented by existing species. Very few Sponges have as yet been found in the British tertiaries.

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[1] The works of Phillips and of M[illegible] should be consulted for these fossils.

On the Continent, between twenty and thirty Sponges have been described from palæozoic strata, and a very great number from secondary rocks.[2] Tertiary sponges have been described by Phillippi, Michelotti, and Michelin.

As our knowledge of the distinguishing characters of existing Sponges is as yet very imperfect, and as the characters upon which species have been founded are in a great measure empirical, the determination of the limits of fossil species is consequently very unsatisfactory, and must not be used in the solution of geological problems without the greatest caution.

Foraminifera have been observed by Professor Phillips in the Devonian limestones of Cannington Park and South Devon. They have been found also in limestones of the carboniferous epoch in Britain. Mr. Rupert Jones has determined several Permian species. Mr. Strickland has described species from the oolites. It is, however, in the cretaceous strata that we first find the species numerous, and many of them very near—some, perhaps, undistinguishable from existing forms. Thirty British cretaceous species are enumerated in Mr. Tennant's catalogue, belonging to the genera *Bulimina* (4 species,) *Cristellaria* (1,) *Dentalina* (3,) *Gaudryina* (1,) *Globigerina* (2,) *Marginulina* (1,) *Rosalina* (3,) *Rotalia* (7,) *Spirolina* (1,) *Textularia* (5,) *Truncatulina* (1,) *Turbinulina* (1.) Foraminifera play an important part in the London clay; but the species have not as yet been carefully investigated. The most important are the Nummulites (*Nummularia elegans*, *Nummularia lævigata*, or *Nummularia variolaria*) which are found in vast numbers in certain beds. The *Foraminifera* of the coralline and red crags have been investigated by Mr. Searles Wood. Several of them are identical with existing species.

On the Continent, Foraminifera occur in vast abundance, in formations of various ages, and have been studied with more attention than in Britain. Alcide D'Orbigny and Ehrenberg are the great authorities on this branch of palæontology. The *Fusulina cylindrica* is a Foraminifer which plays an important part in the upper carboniferous limestone of Russia. The genus *Webbina* has been observed in the lias. Seven species of *Cristellaria* have been found in the "calcaire a polypiers" (oolitic) of Caen. Numerous eocene species have been described from France and Germany, and the great nummulitic limestone of the Mediterranean region. Egypt and Central Asia are characterized by the abundance of individuals of *Nummulinae*. M. A. D'Orbigny has enumerated no fewer than 250 species of cretaceous Foraminifera belonging to thirty genera. In the tertiary strata of the eocene and miocene periods they are extremely abundant. No fewer than 460 species, belonging to fifty-five genera of tertiary Foraminifera, have been enumerated by D'Orbigny. This naturalist has described 900 living species of this tribe. No doubt numerous forms, both living and fossil, remain unrecorded. On the whole, however, we may fairly assert, that the greatest development of these very low but beautiful organisms is in the existing period, and that their numbers increased in successive epochs as we approached the present; in this respect contrasting with the highly organized Cephalopoda, whose shells they simulate, and who were much more numerous and varied during the earlier than during the later epochs of the earth's history.[3]

Infusoria.—The British fossil animals of this tribe may be mentioned here. Many species of Xanthidium occur in chalk flints, also species of the genera *Chætotyphla*, *Fragilaria*, *Peridinium*, and *Pyxidicula*. Fossil Infusoriæ have been observed in pleistocene marls in Ireland, in Scotland, and in North Wales. Very little has as yet been done in Britain towards their investigation. They are, in all probability, abundant in many strata, both tertiary and more ancient.

On the Continent, the researches of Ehrenberg have made known numerous fossil microscopic bodies of this order. They have been found in countless numbers in the substances called Tripoli and Berg-meal, forming silicious deposits of considerable extent and thickness. In Africa, Asia, and America, they have been observed in equal abundance. The eatable earths of several countries are composed of their remains.

PLANTS.

(See Table of British Fossil Plants on Map.)

The oldest traces of vegetable remains are supposed to be the fucoids of the Silurian beds, but there is no clear evidence of their vegetable nature. Our knowledge of Devonian plants is still very obscure. Not so, however, as respects the flora of the carboniferous epoch, at least so far as variety of external forms affords evidence of its extent. Our acquaintance with the internal structure and essential characters of the majority of fossil plants is, in reality, very limited, and likely to remain so. Still, the peculiar characters of the fossil forms, the *Calamites*, *Sigillariæ*, *Lepidodendron*, *Stigmariæ*, &c., of the coal measures, though often empirical, are of very great value to the geologist, and indicate very peculiar conditions of the earth's surface. The existence of such enormous quantities of coal itself bears witness to the extent of vegetation during the epoch of its production. Dicotyledonous trees, especially *Gymnosperms*, allied to the pines and *Araucariæ* of our own times, seem to have been abundant during the same period. The Permian flora has distinct relations with the carboniferous. Of the triassic plants we know but little. In our oolitic strata we find numerous remains of plants, the general assemblage presenting as peculiar a *facies* as that of the carboniferous period. Peculiar forms of Ferns, species of the genera *Pecopteris*, *Sphænopteris*, *Pachypteris*, *Tæniopteris*, *Phlebopteris*, *Otopteris*, *Neuropteris* (1), *Cyclopteris*, and *Alethopteris* mark the epoch. The presence of many species of *Cycadaceæ* within our area is another striking feature of the oolitic flora. Coniferae and more typical forms of Dicotyledons also occur, and remains of several distinct Monocotyledonous genera. In the Wealden we find species of *Sphænopteris*, *Lonchopteris*, *Pterophyllum*, *Equisetites*, *Clathraria*, &c. Several plants, *Cycadaceæ* and *Coniferae* especially, occur in cretaceous beds; and it is an important fact that one of the Wealden forms ranges to the upper beds of the lower green sand. The researches of Mr Bowerbank, in the London clay, have made known a vast number of vegetable remains, and have given us as complete an idea of the vegetation of our area during the eocene period as we have of its carboniferous flora. Our eocene flora appears to have been comparable with that now existing in tropical regions of the East. Remains of Palms, Leguminous plants, Proteaceæ, and Cypress-like Coniferae, especially characterize it. We have few data, scarcely any, wherewith to judge of the British miocene flora. The fossil plants lately found by the Duke of Argyll in Mull are probably of this age: they consist chiefly of the leaves of *Platanaceæ*, *Amentaceæ*, and *Coniferæ*, and were probably part of the same flora with that which formed the "Surturbrand" of Iceland and that discovered by Sir John Richardson on the shores of the American Icy Sea. If so, the climatal character of the polar regions during the Miocene epoch must have been fully as distinct from that prevailing during the glacial epoch or at the present time, as the coal-measure epoch polar climate was. There are indications of similar climatal phenomena in the southern hemisphere. The hypothesis of the gradual diminution of central heat can afford no satisfactory explanation of these curious, and, as yet, but imperfectly noticed phenomena. During the pleistocene epoch it was composed of arctic and sub-arctic species, such as now live in the most northern districts of Europe, and a few of which still remain with us, surviving on the summits of the Scottish and Welsh mountains, which once were islands in the ice-bound pleistocene ocean.

General Note.—Consult, for British fossils generally, Morris's Catalogue of British Fossils, and that of Tennant. In Mantell's Medals of Creation much information will be found. Pictet's Manuel de Paleontologie is one of the best summaries of the state of our knowledge of organic remains. Bronn's Index Palæontologicus is indispensable to every geologist. A. D'Orbigny's Prodrome de Paleontologie is a less complete work of the same nature. Sowerby's Mineral Conchology contains figures of the greater number of described British fossil shells. See also Miller and Austen's Crinoidea. The publications of the Palæontographical Society are indispensable.

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[1] See Annals of Natural History for August 1847.

[2] See especially the figures in Goldfuss, Petrifacta Germanica, vol. i.; in Michelin's Iconographie Zoophytologique; and the works of Roemer on the Oolitic and Cretaceous Formations of North Germany.

[3] The student of the Foraminifera should consult the works of M. D'Orbigny. His volume on the Fossil Foraminifera of the Vienna tertiaries will be found most useful, since it presents a very complete view of the present state of the subject. In Britain we have much to hope from the researches of Mr. Williamson.

EXPLANATION OF THE PLATES.

The Palæontological Map of the British Islands presents the following features:—

1. The area occupied by, and the bounds of, the several geological formations (exclusive of the drift), whether of sedimentary or igneous origin, in the British Islands, laid down from the researches of our ablest geologists.[1]

2. The names of places on the map are for the most part geological localities, either such as are mentioned in geological memoirs, or such as are remarkable for the organic remains found in localities in their neighbourhood.

3. Localities remarkably productive in fossils are marked with asterisks and letters, or signs indicative of the nature of the organic remains which occur in such places.

4. Around the coast the more remarkable or most abundant fossils of the neighbouring country are indicated.

5. The more remarkable phenomena of distribution of life during the pleistocene or glacial epoch, especially such as bear upon the distribution of the existing flora and fauna, are indicated at length in their places, terrestrial and marine, where they occur.

6. Lines of depth are traced around the coast, to mark, as far as possible, on the scale of the map the several zones of depth (Littoral, Laminarian, Coralline, and deep-sea Coral), in the British seas.

7. General and special tables of the numerical distribution of fossils in the principal districts are engraved on the margins. These should be consulted in connection with the text.

8. On the upper margin of the map figures of some of the most remarkable palæozoic, secondary, and tertiary fossils, especially Vertebrata, are engraved.

9. On the lower margin figures of the types of the several groups of the genus Ammonites (see "Cephalopoda" in the text) are engraved. These have been selected for illustrations, on account of the neglect the important generalizations and definitions on this subject, by the illustrious Von Buch, have met with in this country.

10. The elevation of the principal mountains and high regions is stated on the map, in feet above the level of the sea.

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[1] The maps of Greenough, Phillips, Murchison, Griffith, M'Culloch, and the published sheets of the Geological Survey, as well as the numerous maps accompanying special geological memoirs, have been consulted as authorities. The plan of the maps in the Physical Atlas, however, differs materially from that of any published geological map of Great Britain or Ireland.

PLATE 7

THE PHYSICAL FEATURES OF AMERICA:

ITS MOUNTAINS, TABLE-LANDS, PLAINS, AND SLOPES.

I. NORTH AMERICA.

BY PROFESSOR HENRY DARWIN ROGERS, BOSTON.

The primary or grand divisions of the continent are seven in number, consisting of two wide Continental Plains, three great Zones of Mountains, and two narrow Oceanic Slopes.

A The Great Central Plain, extending from the Gulf of Mexico to the Arctic Sea and Hudson Bay, and from the Appalachians to the Rocky Mountains; a vast continental area of table-lands, and plains, and gentle slopes.

B The Appalachian Mountain Zone, or Atlantic Mountain System, rising between the eastern margin of the great central plain and the western limit of the Atlantic Slope, and ranging from Georgia and Alabama to the Gulf of St Lawrence and Labrador.

C The Chippewayan Chain, or Rocky Mountains, a wide and irregular belt of very lofty rugged mountain ranges and high included table-lands and deep valleys, extending from Central America the whole length of the continent to the Arctic Ocean, and bounded on the east by the Great Central Plain, and on the west by the Western Table-land, or Salt and Volcanic Desert.

D The Great Western Desert Plateau, a long elevated belt of table-land between the Rocky Mountains and the Pacific Chain, stretching from the plateaus of Mexico and Gulf of California to the Polar Sea in Russian America, embracing wide rainless salt deserts, lofty volcanic plains, and many rugged stony mountains.

E The Pacific Mountain Zone.—A chain of very lofty mountains, stretching from the Peninsula of California along the whole western side of the Continent to Russian America, and separating the Western Desert Plateau from the Pacific Slope.

F The Pacific or Western Slope, lying between the western base of the Rocky Mountain or Pacific mountain zone and the Pacific Ocean—a narrow, irregular, and sloping surface, extending from Southern California as far as Russian America.

The Atlantic or Eastern Slope, embraced between the Appalachian mountain zone and the Atlantic coast, and extending from the Gulf of Mexico east of the Mississippi, a long and narrow belt, to the Gulf of St Lawrence.

The Volcanic Range of Central America.

In reality, the surface of the continent presents but *two great slopes*,—one extending from the central or true continental mountain-chain, the Chippewayan Range, to the Atlantic Ocean; the other from the same great axis to the Pacific. That elevated zone of mountains is the back-bone or water-shed of the continent, which descends from the high level of from 4000 to 6000 feet at this chain to the horizon of the sea, with only two intervening swells of the crust—those, namely, which support the Atlantic and the Pacific mountains. These oceanic chains are but local water-sheds, for they only partially turn the drainage which descends the respective slopes on which they are seated, some of the largest rivers of which pass across them. The continent also slopes, but more gradually, northward and southward, or towards the Arctic and the Mexican seas, from a broad bulging of its surface, which ranges nearly east and west from Labrador, past the sources of the Missouri to the northern verge of the Utah Desert. These slopes are well indicated in the drainage of the continent.

These principal great divisions of the surface of the continent admit of a natural subdivision into the following secondary belts.

A The Great Central Continental Plain embraces two physically different regions: the first, a western region of elevated table-lands or steppes; the second, an eastern division composed of three great basins or plains of river or lacustrine drainage.

I. The Western Steppes.—These occupy a broad belt, averaging about 350 miles in width, extending northward, parallel with the Rocky Mountains, from near the 28th degree of latitude to the 60th, or probably further. Indeed, the Arctic highlands, or the table-lands north of the Great Slave Lake and east of the Mackenzie river, may be regarded as the prolongation of these elevated plains. In the longitudinal direction, the whole great plateau ascends from its southern or south-eastern border near the Lower Rio Grande to the Upper Missouri, and thence gradually declines again in level to the Arctic Ocean. Between the Arkansas and the Upper Missouri, or from the 38th to the 49th degree of N. latitude, the mean elevation of the whole plateau is about 4000 feet, though the higher western terraces abutting against the base of the Rocky Mountains, as the Laramie plains between the forks of the Nebraska or Platte, and also the lofty plains fronted by the escarpments of the Black Hills, have an average level above the sea of between 5000 and 6000 feet. The western waters of the Arkansas, the Missouri, and the Saskatchewan, having their fountains at the eastern base of the Rocky Mountains, all denote, in their great distance from the sea, the remarkable elevation of this extensive swelling of the continent, which, it is well to note, is opposite in latitude to the highest ridges and table-lands of the Rocky Mountain zone, and also the high lacustrine water-shed between the Mississippi and Hudson Bay basins. The general eastern boundary of this high western table-land of the great central plain is tolerably well defined in its terrace-like escarpment from the Rio Grande near the Presidio, north-eastward to Austin on the Colorado, and thence nearly northward to the Arkansas, following approximately the meridian of 98° W.; but farther to the northward, crossing the Nebraska and the Missouri, it is not so well marked. It is traceable, however, bending a little westward between the Rivière à Jacques and the Missouri, and into the British territory. Throughout this extended line, the edge of the table-land has a mean elevation above the sea of about 2000 feet. From this margin to the base of the Rocky Mountains, the whole zone rises, both with a general slope and by successive and bold terraces. One of these, the most western, is so much more prominent than the rest, the whole way from the Black Hills of the Missouri to the Rio Pecos, near which it ends, that it constitutes a distinct belt, and confers on the general table-land the feature of a division into a lower and a higher plateau. The western or higher range of table-lands—the average breadth of which exceeds 200 miles, and is 300 miles near the Missouri—has its eastern escarpment, overlooking the first or lower plateau, very nearly coincident with the meridian of 101° W. from latitude 32° to the Arkansas, and even to the forks of the Nebraska, and still farther north; but this is best defined between the Pecos and the Canadian rivers. From the Pecos to near the forks of Nebraska, the general height of the margin of this upper plateau is about 3500 feet, or 1000 feet higher than the mean level of the plain to the east of it. Its western margin at the foot of the Rocky Mountains is not lower than 5000 feet. The whole belt from the Pecos to the Missouri is a barren and thirsty desert, without tree or shrub, except along the borders of the attenuated streams, and so scantily fed with rain at certain seasons as to be then nearly without vegetation. North of the Missouri, where there is more rain and less evaporation, the region is better irrigated and more grassy, and embraces, in the British territory, many streams and lakes. All the longest western tributaries of the Mississippi and Missouri, and of the Saskatchewan and Churchill rivers of Hudson Bay, descend eastward across this plateau; while the eastern waters of the Rio Grande and the Mackenzie flow along it, the one southward and the other northward.

The lower terrace or plain, now defined in limits and height, closely resembles the upper one in its level mountainous surface, its wide treeless wastes, and arid summer climate; but it is somewhat more grassy, and in the middle and southern latitudes its broader river-bottoms have thicker belts of trees and a denser verdure. All the rivers from the Arkansas to the Pecos inclusive, issuing from the upper table-land into this lower one, pass out from between confining precipices often several hundred feet high, through narrow sluices (cañons, they are called) of enormous depth. Along the eastern border of this lower treeless plateau there extends from the Brazos to the Arkansas, or for more than 400 miles, a remarkable belt of woodland, from five to twenty-five miles wide, entitled the "Cross Timbers." This narrow zone separates the fertile and well-watered lower plains of Texas, abounding in verdant prairies and clumps of noble trees, from the sterile and naked wastes of the western steppes or table-lands.[1]

In their geological constitution, all these western plateaus of the great plain of the continent belong, from Mexico to beyond the Missouri river, to the cretaceous formation, with here and there local and shallow basins of horizontally stratified eocene tertiary deposits of clays, sands, and marls. The curious belt of the "Cross Timbers" is connected, doubtless, with a line of outcrop of some more than usually fertile and water-bearing stratum of the cretaceous series.

II. The Eastern Basins.—Between the eastern border of these elevated western steppes, and the north-western base of the Appalachian mountain zone—that is, between a western line extending somewhat irregularly from near the 31st parallel and 98th meridian to near Athabasca Lake, or the 60th parallel, and about the 110th meridian, and the foot of the Cumberland and Alleghany Mountains as an eastern limit, in the south-west, the Adirondack and Green Mountains in the middle, and Watchish chain in the north-east—there spreads the broad well-watered lower plain of the great central area of the continent. This vast tract of streams and lakes is nowhere elevated above the sea more than about 1500 feet, and a very large portion of it not more than from 500 to 700 feet. Only along its western border, and at the sources of the Mississippi and the northern feeders of the great St Lawrence lakes, is the surface lifted to the highest of these levels.

This entire region embraces three large natural basins of drainage—that of the Mississippi, and all its affluents east of the high western steppes; that of the Lawrentian lakes, and their tributaries; and that of the southern, western, and eastern feeders of Hudson Bay.

1. *Of the Mississippi Basin.*—The general slope of this wide river-basin is southward, and at a very gentle rate, for its elevation at the mouth of the Missouri is, by Nicollet's determination, but 388 feet; even at the Falls of St Anthony, on the Upper Mississippi, it is only 856 feet. The descent of the two sides of the basin towards the lower central plain of the main Mississippi is likewise very gentle; for Pittsburg, distant nearly 600 miles in a straight line from the great river, is only some 699 feet above the ocean, while the mouth of the Republican fork of the Kansas, 340 miles in the opposite direction, is no more than 927 feet. These levels and distances indicate the general fact, that the western side of the basin slopes much more rapidly to the level of the Mississippi than the eastern. This it does, in conformity with the general eastward subsidence of the whole great central plain; and, indeed, in a wider sense, of the entire continent, from the Rocky Mountains towards the Atlantic coast. A very irregular water-shed, between 1000 and 1400 feet in elevation, separates the Missouri and Mississippi streams, in the north-western border of this basin, from the feeders of Lake Winnipeg, flowing northward towards Hudson Bay; while farther eastward the tributaries of the latter river and of the Ohio are parted from those of the Lawrentian lakes by an eastwardly rising summit not more than 1000 feet above the sea, to the south of Lake Superior, but of the greater height of about 1300 feet bordering Lake Erie. Throughout nearly its whole extent this great plain or basin possesses a soil and climate of rare fertility, and has resources, agricultural, manufacturing, and commercial, which destine it for the abode of an enormous population. Only in its extreme western and north-western belt is the land unfriendly to tillage, while the central and southern divisions are exuberantly rich. Between the western slopes of the Appalachians and the Mississippi, the Wabash and Lake Michigan, almost the whole surface was originally clothed with forest, and much of it still remains so; but west of those limits, to the beginning of the western plateaus or steppes, the vast plain is one succession of gently-rolling grassy prairies, intersected by belts of woodland in the immediate valleys of the streams, and sprinkled in the south-west with parks and clumps of trees. All the northern and eastern districts of this whole plain are underlaid by palæozoic strata, while the region south of the Missouri and west of the Mississippi is in chief part composed of cretaceous and tertiary deposits.

2. *Of the Lawrentian Lake Basin.*—This middle basin, extending from the head of Lake Superior to Lake Ontario and the Ottawa, is separated on the south by the water-shed already spoken of, from the northern waters of the Mississippi and of the Ohio, and on the north, from the southern streams of Hudson Bay, by a somewhat higher water-shed, which ranges from Missabay Heights, where the summit-level is about 1500 feet, keeping north of Lake Superior and the Ottawa, and declining considerably in level to the sources of the Saguenay. The western rim of the basin is only about 50 miles west of the head of Lake Superior, and is formed by a belt of high ground, extending in a north and south direction between the St Louis river of Lake Superior, and the White Swan river and lake of the Upper Mississippi, and uniting the southern and northern water-sheds in about longitude 92° 50′. A remarkable feature in the hydrography of this basin is the enormous proportion of the surface covered by water. In singular contrast with the magnitude of its five great lakes, is the smallness of the area which supplies them, for the water-sheds which encompass the basin, forming its general rim, are in close proximity with these lakes over great distances. On the southern sides of Lakes Superior, Michigan, and Erie, this nearness of the crest of land which separates their waters from those which descend to the Mississippi is especially conspicuous. It is, in many districts, but a *few miles* off from their shores, while some of the streams descending southward from it are more than 2000 miles from the Gulf of Mexico. Yet this seeming anomaly vanishes when we recognise in these lakes their genuine relations to their basin, and view them as only expansions of the upper tributary of the Great St Lawrence river; then their southern water-shed takes its true half-way position between the ocean in the Gulf of St Lawrence, and the same in the Gulf of Mexico. This basin of the five lakes is, in reality, a wide level plateau, moderately depressed within its borders, and falling eastward by small successive stages from an elevation at the surface of Lake Superior, of 628 feet, to one of 232 feet at that of Lake Ontario. It is, in fact, only the eastern extension of the great bulge or plateau which, a little farther westward, and thence to the Rocky Mountains, divorces the head waters of the Mississippi and Missouri from those which run to Hudson Bay, and which, forking into the two enclosing water-sheds of the lacustrine basin, may be viewed as a great transverse or east and west swell of the land, starting from the wide area of highest inflation on the whole continent; that which includes the sources of the Missouri, the Saskatchewan, and the Columbia rivers, and divides the whole central plain into the two main basins of drainage—the basin of Hudson Bay, and that of the Mississippi. This entire Lawrentian basin has its surface thickly sheeted with the northern drift-stratum. Its northern half, from this cause, and from its sub-arctic winters, is sterile, and ungenial to agriculture. The rocky floor of nearly the whole basin is formed of the more ancient palæozoic strata.

3. *Of the Hudson Bay Basin.*—This is a large area, almost rivalling in size the Mississippi basin. A crescent-shaped curving water-shed, commencing on the north-east with the high lands of Labrador and the Watchish Mountains, and extending westward in the Missabay Highlands, separates it from the basin of the St Lawrence, while its S.W. and W. boundary is the vaguely-traced border of the western plateau or steppes, prolonged N.N.W. from the Missouri towards Athabasca Lake. High barren grounds occur north of Athabasca, and to the north and north-west of Chesterfield Inlet and its feeders, and these may be accepted as the border of the lower plain or basin in that direction. This is a region of innumerable tortuous streams, and of inosculating lakes and swamps, converging their drainage into Hudson Bay. The longest western affluent of this great basin, the Saskatchewan, conspicuously rises, like the Missouri, at the eastern base of the first chain of the Rocky Mountains, and descends across the high western table-lands of the great central area, into this more immediate basin of Hudson Bay, the general elevation of the exterior rim of which in but few places exceeds 1600 feet, while the average level of the whole surface is less than one-third of this. It is a cold, inhospitable, and snowy district, its rocks deeply covered with sterile drift, and the surface intersected with a network of waters and wet swamps.

The encircling border or rim of this Hudson Bay basin is a belt of crystalline or primary rocks, chiefly gneissic and granitic, with many trappean dykes; and within this to the shores of the great estuary is a wider, lower, broken, ring-shaped zone of older palæozoic rocks. This concentric relation of the ancient wider shores of palæozoic age to the modern narrower ones of the existing still circular bay or gulf, points to an extensive elevation and contraction of the original oceanic basin, and is certainly an interesting feature in the structure of this part of the continent. It seems to imply that from a very remote geological antiquity, the encompassing plain or basin and enclosed estuary of Hudson Bay have formed together a sunken circular area, which, though greatly lifted since the primary epoch, has not yet been wholly elevated above the ocean level.

B The Appalachian Mountain Zone, or Atlantic mountain system, embraces the whole range of high lands stretching from Northern Alabama and Georgia to the Gulf of St Lawrence and Labrador, and spreading between the great central plain or the Mississippi, Hudson Bay, and Lawrentian lake basins, on the north-west, and the Atlantic slope on the south-east. Its component chains are, first, the Watchish Mountains and high lands north and north-west of the St Lawrence Gulf and River; and secondly, the great Appalachian chain, including the north-eastern group between the Gaspé and the Hudson and Champlain valley, and the south-western group or Appalachians proper, extending from this transverse depression to Northern Alabama. This whole great mountain zone has a total length of nearly 2000 miles, and a breadth varying between 150 and 200 miles. In the chief sections of its length, it is a wide complex belt of many parallel ridges, few of whose crests ascend to 4000 feet above the sea; their bases resting on a plateau, the central or most lifted line of which is in two or three districts, 1800 or 2000 feet above the same plane of reference.

From Alabama to the Hudson river valley, the Appalachian chain is the water-shed between the rivers descending south-eastward to the Atlantic, and those running north-westward into the Ohio and Lake Ontario, and from the Hudson to the Gulf of St Lawrence, it divides those flowing to the Atlantic from the shorter ones seeking the St Lawrence. The detached northern chain, or hilly zone of Lower Canada and Labrador, is a third separate line of water-shed, parting the streams that drain south-eastward to the St Lawrence from those falling westward to enter Hudson Bay. The entire mountain zone is thus separated into three chains or water-sheds by the oblique transverse depressions of the Hudson and Champlain trough, and that of the great St Lawrence; but as the south-western and middle ones are intimately connected across the Hudson valley, it will be best to view these as one mountain system. To a more detailed description of this, under the special name of the Appalachian chain, we will now proceed.

1.—*The Appalachian System, or Alleghanies, Green Mountains, White Mountains, &c.*—This is a broad and lengthened chain of approximately parallel mountain ridges and included high plateaus, extending from the Gulf of St Lawrence to the northern parts of Georgia and Alabama; in total length about 1550 miles, embraced between the 49th and 33d degrees of N. latitude. The whole belt ranges nearly centrally from N.E. to S.W., along the extensive table-land which lies between the Atlantic Ocean on the S.E., and the St Lawrence and Mississippi on the N.W. and W., and it is the great water-shed dividing the streams which descend in these two opposite directions. The mean elevation of these mountains is about 2500 feet, though some of the higher and more prolonged ranges have an altitude of 3500 feet, or even 4000 feet above the sea. These do not in many instances rise more than 2000 feet above their adjoining valleys, while the lesser ridges attain a height of not more than from 800 to 1500 feet. The general base or bulging plateau on which the Appalachians rest, swells in two districts to an elevation approaching 2000 feet above the sea. One of these is in the White Mountains, eastward of the sources of the Connecticut; and the other is in the south-western corner of Virginia, adjoining the north-west corner of North Carolina. These are likewise the districts where the two great divisions of the chain, the north-eastern and south-western, culminate.

A. *North-Eastern Group.*—This natural primary subdivision of the entire Appalachian chain is almost insulated from the other or south-western group, by the great transverse depression of the general surface which unites the estuary of the Hudson with the valley of the St Lawrence, through the Hudson valley, the low basin of Lake Champlain and the valley of the Richelieu, and the highest part of which trough, or the water-shed between the Hudson and Lake Champlain, is only about 124 feet above the level of the sea. A subsidence of the continent here, to a depth of only 300 feet, would let the ocean through from the Gulf of St Lawrence to the Bay of New York, and there interpose a strait nearly as wide as that between England and the European continent, forming an island of the New England States, New Brunswick, and Nova Scotia. Geological evidence proves this insulation to have actually occurred in the pleistocene tertiary period.

The principal range of this north eastern group, both as respects continuous length and mass, is that of the Green Mountains. This long belt of parallel ridges and swelling summits has its greatest elevation in Vermont, where a few of the loftier rounded crests surpass the height of 4000 feet. In ranging N.N.E. past the sources of the Connecticut, and thence north-eastward, it becomes the water-shed between the St Lawrence and the Atlantic streams, holding an average height of about 2000 feet to the sources of the Wallocstook. More broken and interrupted, the same general mountainous and hilly zone follows parallel with the St Lawrence, until it is seen in the Shickshock and Nôtre Dame Mountains in the peninsula of Gaspé. In the opposite or south-western direction, the Green Mountains gradually contract in elevation and breadth from Vermont, to where they are cut to their base by the tidal valley of the Hudson. Thence, under the name of the Highlands in New York and New Jersey, and of the South Mountain in Pennsylvania, the chain subsides from a mean height of 1600 feet to one of 600 or 700 feet, crosses the Delaware, and expires on reaching the Schuylkill at Reading. The portion between the Hudson valley and the Schuylkill belongs in strictness to the south-western Appalachian group, but [illegible] prolonged from the main range of the north-eastern, it is the vinculum which binds the two divisions across the Hudson into one great connected mountain chain or system.

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[1] See Captain Marcy's Report on Exploration of Head waters of Red River.

Its detached Mountain Masses.—In proximity with this chief north-eastern chain which, southward of Lake Champlain, becomes a more and more local water-shed, there exist several interesting, isolated, high mountain groups, composed of granitic, gneissic, and ancient azoic rocks. The most prominent of these groups are the White Mountains of New Hampshire, and the Adirondack group W. of Lake Champlain. The White Mountains, strictly limited, are scarcely one degree in length, but they embrace the loftiest summits of the Appalachian system. Mount Washington, the culminating point, is 6428 feet high; Mount Adams, 5960; and Mount Jefferson, 5860 feet. The Adirondack group, the eastern half of which is very mountainous, occupies the triangular area enclosed by the St Lawrence, Lake Champlain, and the Mohawk. The summit called High Peak is 5467 feet high, and there are others almost as lofty. This mountain group consists of chains of elevated hills and irregular crests, linked in nearly parallel N.N.E. and S.S.W. order. The central axis of the White Mountains observes nearly the same direction. To the north-eastward of the White Mountains, and in similar position on the Atlantic slope of the St Lawrence-Atlantic water-shed are various other isolated granitic mountain groups. Of these the loftiest is Katahdin in Maine, 5360 feet high.

II. *South-western Group, or Appalachians proper.*—From the Hudson and the Mohawk south-westward to Northern Alabama and Georgia, extends the other great division of the Appalachian chain, familiarly called in the Middle States the Alleghany Mountains. This remarkable zone of high lands has its distinguishing features in the marked parallelism, great length, narrowness, steepness, and level outline of its multitudinous ridges. It is a complex chain, but embraces three natural great divisions, parallel with each other throughout their entire length.

1. *The South-eastern Belt*, the most uneven, undulating, and picturesque in its crest line and slopes, is the broad high range, called in Virginia the *Blue Ridge*, and in North Carolina, Georgia, and Tennessee, Smoky or Unaka Mountains. This chain, almost identical in geological composition and structure with the Green Mountains of Vermont, and resembling them strikingly in contour and scenery, lies nearly in their prolongation, that mountain zone terminating at the Schuylkill, and this commencing just S.W. of the Susquehanna. Here it begins as a broad group of parallel, undulating, coalescing ridges; but S. of the Potomac it becomes broader and more prominent, displaying great bulk and relative elevation, from where it passes the James River of Virginia, to where it commences to break up and subside in south-eastern Tennessee and Georgia. In its northern half, its average breadth is about 15 miles, and its crest has an undulating height of 1500 to 3000 feet. In North Carolina and Tennessee it is more than twice as broad, and the highest peaks rise to between 4000 and 5000 feet above the sea. The rocks of both the Blue Ridge and Green Mountain chains are chiefly ancient metamorphic strata, as gneiss, talcose, and chloritic schists, and highly altered argillaceous and sandy strata at the base of the palæozoic deposits, including some of the oldest fossiliferous beds. All these stratified masses are extensively penetrated by igneous dykes and veins.

2. *The Middle Appalachian Belt* is separated from the Blue Ridge by a long continuous plain called the Great Appalachian Valley, which, in an average width of 15 miles, ranges longitudinally from the St Lawrence to Alabama. This central chain is a broad zone of long, narrow, and level ridges, separated by long and narrow valleys, and cut to their bases by many notches and defiles, through which the streams take their transverse flow. These ridges, the results of a diffused but excessively energetic erosion of great parallel undulations of the crust by oceanic waters, are distributed in variously connected groups, in nearly all of which the several crests are remarkably parallel, and either singularly straight for great distances, or gently curving. In many instances these ridges unite by couples, either at one or both extremities, to enclose long and tapering valleys, into which the only ready access is often by the transverse gaps or notches. Separating the larger natural groups of long, narrow, parallel mountains, are wider mountain table-lands of the general height of the surrounding level ridges; and in many cases the ridges merge into the plateaus, as the fingers do into the hand. The plateau of the Catskill Mountain is but the general north-eastern termination of this middle chain, where a number of its ridges, straight and narrow crests in Pennsylvania, coalesce on passing the Lehigh to form between this river and the Mohawk the widest and longest of the table-lands of the whole middle belt. The rocks of this long central chain are exclusively palæozoic strata, from the base of that system to the coal inclusive, and scarcely a mineral vein or igneous dyke intrudes itself into all the belt. The southern termination of this middle zone is in the north-eastern corner of Alabama.

3. *The North-Western Belt* is the long and relatively narrow high table-land of the Alleghany Mountain of Pennsylvania, Sewell Mountain of Virginia, and Cumberland Mountain of Tennessee, which presents a bold escarped slope, fronting south-eastward the middle chain almost continuously from the north-eastern corner of Pennsylvania, where the plateau rises to the middle of northern Alabama, where it ends in the spurs of the Cumberland Mountain. This mountain table-land, consisting of nearly horizontal strata supporting an extensive coal-formation, is undulated along its south-eastern edge by a few very long regular parallel narrow ridges, which are much farther asunder and more depressed, and wider and rounder at their crests, than those of the adjoining middle chain, and these undulations become progressively feebler as the plateau spreads to the north-west, and gradually slopes down through western Pennsylvania, and Virginia, and eastern Kentucky, into the broad plain watered by the eastern and southern tributaries of the Ohio river.

A general longitudinal survey of the entire Appalachian chain, from New Brunswick to Alabama, displays a belt quite undulating in its line of direction, and composed of some *ten distinct sections*. The first of these, that of the *St Lawrence*, extends from Gaspé to the sources of the Connecticut, and is *convex* to the N.W. The second is the special range of the *Green Mountains*, nearly straight from the Canadian line to the banks of the Hudson, where the belt begins rapidly to elbow. This section runs S. 15° W. The third, or *Delaware division*, is a gradually bending section, curving *concavely* north-westward from the Hudson to the Lehigh. The fourth is a *straight* division, between the Lehigh and the Susquehanna, ranging S. 70° W., including all the *anthracite* basins of Pennsylvania. The fifth, or *Juniata division*, curves southward from the Susquehanna to the Maryland line, or is *convex* north-westward, its trend altering to S. 30° W. or as much as 40°. The sixth, or *Potomac* section, is *straight*, extending from Maryland to the centre of Virginia, in a strike about S. 30° W. The seventh, or *James River* section, extends from Augusta, in the centre of Virginia, to the New River; it forms a sweep, concave to the N.W. The eighth, or *Holston division*, is a straight one again, having its crests and valleys running about S. 67° W., and it is 200 miles long. The ninth, or *Hiwassee division*, in eastern Tennessee, is a curving section, *convex* to the N.W., deflecting to S. 35° W. And the tenth, or *Alabama division*, is a long and *straight* one, stretching from the Clinch river to near Tuscaloosa, in the centre of Alabama. In this terminal section the strike of the axes and crests is about S. 36° W.

Ozark Mountains.—The Ozark Mountains extend in a S.W. course, in a direction parallel with the Appalachians, from the Missouri, near the Osage, to the Red River. They belong in strictness neither to the Appalachians nor to the Rocky Mountains, though it is obvious, from their coincidence with the former in geological age, structure, and direction, that they are related to them in physical origin.

The Cordilleras or Andes of North America.—Viewed as a continuous broad elevated belt of great parallel mountain-chains and high included table-lands, this commencing south with the plateaus and cordilleras of Mexico and California, and ending on the north in the broken ridges of Russian America, is one of the largest and loftiest of the mountain systems of the globe. It is a broad, lifted, irregularly-crested wave of the surface, occupying the whole western side of the continent, and much exceeds, in its solid bulk above the level of the ocean, even the Andes of South America, being twice as broad as that mighty chain, and almost as long. It is not less than 4000 miles in stretch from the southern plateau of Mexico to Behring Strait and the arctic coast. It embraces three distinct grand parallel belts: first, on the east, the lofty Chippewyans or double chain of the Rocky Mountains proper; secondly, a range of high, and wide, and broken table-lands, lying west of that chain; and thirdly, bounding the table-lands and overlooking the narrow Pacific slope, a still more lofty mountain-chain, partially volcanic, and extremely rugged and convulsed, the Pacific Alps of the N.W. coast, the Cascade range of Oregon, and the Sierra Nevada and Peninsular range of California.

C The Chippewayan Chain or Rocky Mountain Zone.—This very elevated and rather complex system of mountain crests and included table-lands embraces generally two, and in some districts three, principal mountain ranges. These, and their component ridges, are for long distances approximately parallel; but their lesser sections variously diverge and inosculate. Their crest-lines are wildly undulated, and in some districts sharply serrated like the Alps of Europe. The great eastern range lifts itself out of the western edge of the high table-lands, or level steppes, of the central continental plain, like a huge colossal wall, deeply indented and gashed on its steep flank, and with vast mountain buttresses jutting forward into the desert plateau. The whole chain includes, longitudinally, many sections, separated by the river passes which break it, and by the actual interruptions of the leading crests, which are not in strictly continuous lines. The chief rivers and streams pass round the ends of the long ridges, rather than through true gorges cutting them. It is this recently-disclosed important feature which presents unlooked-for facilities for carrying railroads through this broad and lofty mountain chain, linking the Atlantic basins with the Pacific coast, by avenues of easy commerce, without lifting the roadways materially above the table-lands on which the ridges rest. In northern Mexico, the eastern range is called the Cordillera of Cohahuela and Potosi, the Guadeloupe mountains being only an eastern outlying branch; and the western range is the Sierra de los Mimbres and Sierra Madre. Further north, at the sources of the Arkansas, the eastern belt is the Moro, and Chowatche, or Wet Mountain; and the western the Sierra Verde or San Juan. These two ranges enclose between them the noble valley of Santa Fé, or of the Rio del Norte, a fertile plain, nearly 50 miles broad at its northern end. Between this high plain descending southward to the Gulf of Mexico, and the great middle table-land—here the basin of the Colorado of California—there interposes no mountain axis whatever, the water-shed of the eastern and the western waters being on a level plain at the northern end of the San Juan or Sierra Verde range, in a noble passway some 8 miles broad, and elevated about 9000 feet above the ocean. From the Arkansas to the north fork of the Platte, the chain is more complex and triple; and its eastern range, including the Medicine Bow Mountains, contains some of the highest summits in the whole chain: such are the Spanish Peaks, and Pike's, Long's, and Laramie's Peaks, which rise to 10,000 and 12,000 feet above the sea. North of the main Platte or Sweet Water, is the loftiest section of the whole chain, that of the Wind-River Mountains, where Fremont's Peak has an elevation of 13,568 feet. This great mountain axis is the central water-shed of the whole continent; for from its flanks descend the head streams of the Missouri, which flows towards the Atlantic, and those of the Columbia and Rio Colorado, going westward to the Pacific. West of the Wind-River range, and diverging from it southward, near lat. 44°, occurs the northern end of the Wahsatch range, a long and lofty mountain axis, which passes west of the Green River or Upper Colorado, and forms the eastern boundary of the great Utah basin. This is not strictly a ridge of the proper Rocky Mountain chain, but of the Desert table-lands, for though it originates near that chain, its trend and structure are different. In its southern prolongation it sweeps considerably westward, bounding the great insulated Utah plateau or basin on the S.E. To the northward of the Wind-River range, the main axis, which is here the eastern one, is exceedingly high where it separates the middle and northern sources of the Columbia river from the streams of the Missouri and Saskatchewan. Near the head of the latter towers the great peak of Mount Hooker, 15,700 feet above the sea; and a little further north, that of Mount Brown, 15,990 feet high, the feeder of the river Athabaska. From this culminating part of the chain northward, the crest gradually declines in level to the Arctic Ocean; but even in lat. 62°, its height is estimated at between 3000 and 4000 feet. Beyond lat. 55°, the main eastern range ceases to be the water-shed of the drainage to the Pacific on the one side, and of Hudson Bay and the Arctic Sea on the other; for the Peach River first, and more northward the Liards or Mackenzie, cleave this great chain, and have their water-sheds in ranges further west. A corresponding feature is presented in the southern part of the chain, where the Rio del Norte breaks through the great eastern ridge, and takes its rise in the wide level pass already mentioned among the western spurs.[1]

The geological constitution of the true Rocky Mountain chain is imperfectly known. Granitic and gneissic rocks, and various Palæozoic strata, including Carboniferous limestones, have however been observed in many latitudes. Between the loftier ridges rest high plateaus, composed apparently of cretaceous and tertiary deposits.

D The Great Western Desert Plateau.—This wide and elevated desert belt, embraced between the Rocky Mountains proper on the E., and the Pacific Alps, Cascade range, and Sierra Nevada on the W., and stretching from the Gulf of California to the Arctic Ocean, is of great breadth and height, especially in its central area, between lat. 35° and 45°, where it spreads from long. 107° to 120°, and has a mean elevation above the sea of nearly 5000 feet. It is naturally separated into three great regions: a central one, here indicated; a southern area, divided from this by the Wahsatch Mountains, and an elevated margin extending from these south-westward towards the Sierra Nevada, in about lat. 37½°; and thirdly, a northern region, separated from the central by mountain ranges S. and S.W. of the Columbia, and its great branch the Snake River.

The *Central Plateau* of the Desert zone, the great basin of Utah, is an enclosed or continental river basin, its scanty drainage insulated from the sea by partially encircling mountains, and its surface a succession of vast elevated desert steppes or arid plains, many of which are salt, divided by nearly parallel N. and S. trending mountain-ridges. It is a region of deficient rain, of dry winds, and much evaporation, and has consequently but few and slender streams. The chief of these yet discovered, is that which has received from Fremont, the first geographical explorer of this basin, the honoured name of Humboldt. All the rivers terminate in lakes, which, without exception, are destitute of outlets to the sea, though a few of them pour their waters into others. This drainage in all the larger of these receptacles is more or less saline, and some of the lakes—the so-called Great Salt Lake, for example—are charged with common salt almost to saturation.[2] These lakes are quite numerous; the best known are the Utah and Great Salt Lakes, Nicollet Lake, and others to the west of the Wahsatch ranges; and a long succession probably less saline—as Summer, Albert, Christmas, Pyramid, and Mud Lakes, and Humboldt, Carson, Walker, and Owen Lakes, with several more, seated to the eastward of the Sierra Nevada. On the E. and S.E., this high basin is insulated from the wide valley or basin of the Rio Colorado, a part of the southern middle table-land, by the lofty but irregular chain of the Wahsatch Mountains, but subsides into it southward; and on its western side, from the valley of California, by the almost unbroken crest of the Sierra Nevada. It is in the parallel of this high plateau of Utah that the highest part of the eastern or Missouri slope exists. Across the whole continent there ranges, indeed, one great east and west extending swell of the land, including not only the Utah basin and the Black Hills, but the whole water-shed dividing the upper Mississippi and the Lawrentian lakes from the drainage of Hudson Bay.

The *Southern Basin* of the Great Western Desert zone, is that of the Rio Colorado and Gulf of California. The prolongation southward from the Wahsatch chain to Mexico, of the interior plateau, presents the same succession of table-lands and mountain-ridges between the proper Rocky Mountains and the great Californian chain, which characterise the enclosed Utah basin. It is, however, better fed with rain, has larger rivers, and a surface which, though semi-desert in some of the interior districts, is fruitful enough in others. This greater humidity is due to its moister winds, the lower level of the coast mountains precipitating a less proportion of their aqueous vapour than is arrested by the loftier crests of the Sierra Nevada further north. The general slope of this area is westward and gently southward, and it reaches the ocean level in the Gulf of California. North of the Gila, it is a region chiefly of desert table-lands, very little explored; but south of it, and east of the Gulf of California to the table-land of Mexico, are many fertile and well-watered valleys in the plateau of Sonora. Strictly, the Utah Desert extends to the mouth of the Rio Colorado.

North of the Great Salt Basin there ranges, for half the length of the continent, the northern extension of the *Desert Plateau*, west of the Rocky Mountain zone. Like the southern, this great trough contracts and descends in the direction of its length, sloping eastward, and also gently northward to the Arctic Ocean. In its southern and broadest part it is drained by the widespread affluents of the Columbia River. Between the main crest of the Rocky Mountains and the Cascade range, north of lat. 50°, it is more contracted, and there contains the basin of Frazer River, and north of this the Simpson River. These, and the great Columbia River, pass westward out of this valley to the Pacific, through the lofty coast chain or Pacific Alps, of which the Cascade range is the southern extension. Still farther to the N.W., beyond the south-western sources of the Mackenzie, this long belt is longitudinally drained by the great river Yukon, which reaches the sea in Russian America, in Norton Sound of Behring Strait.

The belt of country now before us, little known in its topography to any but the roving Indians, and the thinly-scattered fur-trappers of the Hudson Bay Company, has an undulating surface of fertile valleys and table-lands, embracing also, in the basin of the Columbia, high rugged volcanic plains. It possesses a mild and humid climate, is copiously watered, contains many lakes, and feeds some of the largest rivers of the continent.

E The Pacific Mountain Chain, including the Pacific Alps, the Cascade range of Oregon, Sierra Nevada of California, and California Peninsular chain, is the third or western belt of the great elevated western mountain-zone of North America. It observes a general parallelism with the eastern or proper Rocky Mountain chain, and ranges from the peninsula of California, where it is comparatively low, northward, with augmenting height and breadth, till it becomes in the northern part of California, and thence the whole distance to Russian America, a wide, complex, and very elevated chain of mountains. Indeed, in this long course, its main central crests and loftiest peaks surpass in elevation those of the highest parts of the rival system of the Rocky Mountains. In Lower or Peninsular California, where it bears the name locally of Sierra de St Lucia, it is a single ridge; but it forks in lat. 35°, to admit between its main or eastern range the Sierra Nevada, and its inferior western branch, the "Coast range,"—the gold-producing valley of California. The Sierra Nevada, a great water-shed, insulating the closed, elevated plateau of Utah from the basin of California and the sea, seems to lose its crest feature towards its northern end. Passing lat. 42°, it curves off somewhat eastwardly towards the Snake River; and between it and the Pacific Ocean there rises the Cascade range, the loftiest division of the entire chain. This latter, embracing first between it and the Sierra Nevada, the Feather River, extends northward, across the Columbia and Frazer Rivers, and thence more north-westward to Russian America, where it curves still more to the westward, and at last hooks round to prolong itself in the high volcanic axis of Aliaska. The Cascade range contains, in the vicinity of the Columbia River, the three colossal peaks of Mount Jefferson, Mount Hood, and Mount St Helens, which tower to 15,500 feet, and even higher, above the level of the sea. St Helens and Mount Regnier are living, though rather torpid, volcanoes. Mount Fairweather, 14,782 feet high, and Mount St Elias, 17,850 feet, the culminating summit of the whole chain, and loftiest point on the continent, are both volcanoes, and are supposed to be occasionally in eruption. Though thus considerably higher than the opposite portions of the Rocky Mountain chain, this great coast-range is not the water-shed of the whole mountain zone, but is breeched to its base in many places, allowing passage to the vast drainage which descends from the Rocky Mountains by the channels of the Columbia, and the several other large rivers of the middle belt.

The "Coast Mountains" of California and Oregon, a local chain west of the Sacramento and Wahlahmath valleys, and closely bordering the Pacific shore, ranges in a somewhat broken line, from its place of divergence from the Sierra Nevada, the whole distance to Vancouver Island.

F The Pacific or Western Slope.—This is the very long, but comparatively narrow belt, included between the Great Pacific chain, above described, and the western shore of the continent. In the peninsula of California it is a slender tract, sloping rather steeply to the sea; but north of lat. 34° it widens, and by the introduction of the locally called "Coast Mountains" which enclose the broad valley of Upper California between them and the great mountain-chain, it becomes more diversified, including here *three* belts in place of one. The true Pacific slope is in this district not the mere narrow western fringe, but the whole continental slope from the Sierra Nevada to the sea. It has here an average breadth of about 100 miles. North of the valley of California, or beyond the Klamath River, the zone maintains about this mean width the whole way to the parallel of 60°, but grows somewhat broader from Vancouver Island northward. The immediate "Coast range" running on, as far as this great island—the central axis of which, indeed, may be viewed as its prolongation—the zone is here, as in California, more or less separated into three parallel belts, the Wahlahmath valley being the most eastern. North of the Columbia River the zone becomes much indented on its coast margin by estuaries and straits, fringing it with many islands. On its continental side it is penetrated by great spurs from the volcanic chain of the Cascade range, and the Pacific Alps.

G The Atlantic or Eastern Slope.—This is the long and rather slender zone extending from the Gulf of St Lawrence to the Gulf of Mexico, and gently sloping breadthwise from the south-eastern base of the Appalachian chain to the Atlantic shore. It embraces several marked divisions, or subordinate belts, distinguished by their physical features no less than by their geological structure. One natural subdivision ranges from the St Lawrence Gulf to the valley of the Hudson, contracting from a width of above 150 miles to a breadth of 50. This belt, with a general and gentle slope south-eastward towards the Atlantic, has a hilly and diversified surface, and a considerably undulated profile in the direction of its length, being transversely penetrated by many river-valleys, which cut it down to the tidal level within their borders and inland from the coast even for many miles, leaving between them parallel descending water-sheds. Its surface is furthermore varied by innumerable insulated hills, and short chains of rounded eminences, some few of which claim the title of mountains; and the whole is intimately and minutely diversified in feature by a wavy outline of mounds and depressions, carved in the deep drift stratum which covers the more sharply irregular rocky floor of the district. This region is distinguished, like the north-eastern Appalachian zone bordering upon it, by its multitude of clear lakes and limpid ponds, and generally by the absence from all its waters of that turbidness which belongs to the rivers of the south-western half of the Atlantic slope.

This frequency of lakes, and transparency of the waters, are simple consequences of the drift-covering which overspreads the country, which causes the basin-like excavations on the one hand, and a filtering action, on the other, freeing its drainage from mud. Into the seaboard margin of this zone, the tide penetrates quite far in several of the rivers, as the St John, Penobscot, and Kenebeck, yet it does not embrace a true tide-water plain, such as constitutes a distinct subordinate belt, in the Atlantic slope south of the Hudson. In New Hampshire, the Atlantic slope extends from the base of the outer south-eastern spurs of the White Mountains to the sea; in Massachusetts, it descends from the water-shed of Worcester county; and in New York from the foot of the highlands, or Green Mountain range, to Long Island Sound.

The other great division, or south-western section of the Atlantic slope, ranging from the Hudson valley to the Gulf of Mexico, expands in breadth south-westward, just as the New England section widens towards the N.E. This south-western portion, bounded on the N.W. by the first ridges of the Appalachians of the middle and southern States, expands rapidly through New Jersey and Pennsylvania, and continues steadily enlarging beyond the Susquehanna and its estuary, the Chesapeake Bay, to an average width of at least 200

[1] See Benton's *Letter to the People of the Missouri on the Pacific Railway.*

[2] For a discussion of the causes of this impregnation, see p. 56, Notes on Continental Basins, *Physical Atlas.*

miles, excluding the peninsula of Florida. At its south-western extremity, this slope or plain, partaking of the southward inclination of the whole continent in that quarter, as marked by the drainage of the Mississippi and all the other rivers entering the northern side of the Gulf of Mexico, slants, not south-eastward towards the Atlantic, but more nearly southward, to the Mexican Gulf.

From Long Island to the southern end of the Appalachian chain, the Atlantic slope presents two belts, quite distinct in their physical features: the one, a true slope descending from the base of the mountains to a generally well-defined boundary; the other, a low and nearly level tertiary plain, embraced between the foot of this slope and the margin of the sea. The boundary between the slope and the plain coincides with the well-marked limit between the running water and the tide, in all the chief Atlantic rivers south-westward from the Hudson to the Roanoke, passing Trenton, Philadelphia, Havre-de-Grace, Baltimore, Washington, Richmond, and Halifax, in North Carolina; thence, trending more inland than the north-western limit of tide-water in the southern rivers, it is approximately indicated by a line through Fayetteville, Columbia, Augusta, and on to Claiborne in Alabama. From Long Island Sound to the Roanoke, a somewhat abrupt change in the physical aspect of the surface, defining clearly in the sudden alteration of level, a line of ancient sea-coast traces this important limit, which, as the inland margin of tidal navigation, has become the seat of the chief maritime cities south of New York.

The upper belt, or *Appalachian Slope-proper*—as this part of the whole Atlantic slope may conveniently be designated—traced longitudinally along its north-western margin, ascends from the level of the tide, at the Hudson valley, to a culminating height, at the sources of the Roanoke, of more than 1000 feet, declining again, beyond the Catawba, to a much more moderate level in middle Alabama. From Long Island Sound to the Potomac, this sloping plain presents a pleasing variety of surface, derived from its varied geological composition—its rocks being those of the gneissic series, supporting the most ancient palæozoic formations, and these overlaid by a broad belt of fertile red shales of Oolitic age. Broad, fruitful, and salubrious valleys, and low wooded ridges and hills of trappean and other igneous rocks, and a kindly soil watered by innumerable brooks, but nowhere marshy, render this Appalachian slope of the middle States one of the most attractive and richest districts on the continent. From the Potomac south-westward, the external features are more monotonous, being those of a wide sloping plain, still much wooded, with occasional rugged ridges. It has a poorer soil, of light sands and meagre clays, derived largely from subjacent talcose and chloritic schists, and other altered azoic rocks, and readily washed and gashed by the hard rains of the climate, and parched by its burning heats. To these qualities of its soil and climate are due the excessive turbidness of the swiftly flowing rivers of this district, and many of the distinctive features of the coast, where the sediments which they carry forward are precipitated. A highly picturesque and fertile tract bounds this sloping plain, at the base of the Blue ridge in Virginia and North Carolina. It is a narrow belt, embracing the outlying hills of the Appalachians, and is called the Piedmont country.

The Atlantic Plain, or seaboard belt of the general Atlantic slope, penetrated, as said before, to its north-western border by the tide-water, from Long Island to the Roanoke, rises nowhere more than perhaps 100 feet above the ocean level, in even its highest districts in the southern States. From Long Island Sound to beyond the Cape Fear River, the mean height of this plain scarcely exceeds 50 feet. It is composed chiefly of middle tertiary sands, clays, and marls, with an outcrop of eocene sands along its north-western confine; and in New Jersey and Delaware, a band of cretaceous pulverulent green sands occupies the same position. The surface for the most part is very sandy, though productive when skilfully tilled. Though intersected with innumerable tidal creeks, this region, as far southward as North Carolina, is not marshy, except near the ocean, and the Delaware and Chesapeake estuaries; but further to the south-west, through North and South Carolina, Georgia, and Florida, its seaward half is much overflowed, and excessively swampy.

THE VOLCANIC RANGE OF CENTRAL AMERICA extends over a length of 1200 miles, from the Isthmus of Panama to the Isthmus of Tehuantepec, and is divided into three groups.

1. *Group of Costa Rica.*—On the Isthmus of Panama the hills are isolated and low, the highest point being only 633 feet above the sea, but in the meridian of the small river Coclet the mountains rise precipitously to form the Cordillera of Veragua, which rises to about 9000 feet, and unites with the Cordillera of Salamanca. On the west side of this chain is the mine of Tisingal, celebrated for the vast amount of gold extracted from it, and from which the country derived its distinctive name of Costa Rica (rich coast). About lat. 9° 25′ N. rises the middle or proper group of Costa Rica, a table-land of little extent, but considerable elevation, which appears to consist of two or three terraces. The town of Cartago is situated at an elevation of 5000 feet; San José, 4600 feet; Villa Vieja, 4230 feet; and Alazuela, 3600 feet. This table-land, which is surrounded by volcanoes, rises gently from the west, but sinks suddenly on the east towards the Caribbean Sea.

2. *The Group of Honduras and Nicaragua* is separated from the former by the Lake of Nicaragua and the River San Juan. The peninsula, which is here about 20 miles broad, rises only to 141 feet above the level of the sea, and 13 feet above the surface of the lake; but on the northern side of the lake, the edge of the plateau forming its western limit rises abruptly to a height of 8200 feet near the village of Tagusigalpa. This ridge extends north to the coast, and is 3000 feet high at Cape Camaron. The whole of the Mosquito coast is low.

3. *The Group of Guatemala* is remarkable for containing the greatest number of volcanoes known to exist anywhere on the surface of the globe, except in the Island of Java, (see Phenomena of Volcanic Action, Plate 10, page 37). The table-land of Guatemala consists of undulating verdant plains of great extent, at an elevation of about 5000 feet. The cities of Old and New Guatemala, about 12 miles apart, are situated on the southern portion of the table-land. West from the new city, the volcano of Pacaya is more than 7000 feet in elevation, and south of the old city the volcano of Agua, which is verdant to the summit, is 15,000 feet above the sea, forming the culminating point not only of Guatemala, but of the entire mountain-system of Central America. Near the Bay of Honduras, the Peak of Congrehoy has an elevation of 7482 feet; on the south of the Bay, the mountain of Omoa rises to 7000 feet, and near its northern shore the Coxcomb Mountain has an elevation of 4000 feet. The shores of the Bay of Honduras are low, but the surface rises gradually in the interior into bold highlands, with numerous rivers and lagoons, and it is covered with magnificent forests.

System of the Antilles.—The portion of the West India Islands embraced in the map presents the most marked contrasts in physical formation: the Bahama Islands, or Lucayos, consisting of a vast number of small low flat islands, are situated on banks of sand and coral, and surrounded by reefs, rocks, and shoals; while Cuba has a chain of mountains extending nearly the whole length of the island, and rising in the S.E., the Montanos del Cobre, to a height of 6890 feet. Hayti is traversed by parallel mountain chains, Mount Chaco being upwards of 6900 feet high; and Jamaica is traversed throughout its whole length, from E. to W., by the Blue Mountains, varying from 5000 to 6000 feet above the sea.

Table-land of Mexico, or Anahuac.—The great mountain-chain which enters the Mexican confederation from Central America, diverges, on extending northwards, into two great and several subordinate branches, of which the Cordillera of Cohahuela and Potosi on the N.E., and the Sierra Madre and the coast-range on the S.W., enclose the table-land of Anahuac, situated at an elevation of 6000 to 8000 feet above the sea. The plateau is traversed in some places by well-defined ridges, but in others the surface is unbroken either by hills or depressions, so that the direction of the cordillera is indicated rather by the table-land than by the mountain chains. Mexico, the capital—the absolute elevation of which above the sea (7471 feet) is more than double that of Snowdon—is surrounded by the valley of Toluca, 8570 feet; the plain of Actopan, 6450 feet; the valley of Istla, 3320 feet; and the plain of Tenochtitlan, 7470 feet above the sea. The latter of these plains is surrounded by ridges of porphyritic and basaltic rocks, in a direction S.S.E. and N.N.W. It is of an elliptic form, 55 miles long and 35 broad. On its south-eastern and highest side are seen towering above the plain the volcano of Popocatepetl, the culminating point of the Mexican system, north-west of which the volcano of Istaccihuatl is 15,705 feet; Cofre de Perote, 13,416 feet; and Citlaltepetl or Orizaba, on the east, 17,374 feet above the level of the sea. East from Mexico, in the direction of Vera Cruz, the plateau maintains its level for 200 miles, when it sinks at once into the plain at an elevation of 3000 feet. On the west the table-land sinks gradually into the plain at a distance of 60 miles. This western side of the table-land is traversed by four longitudinal valleys, rising gradually one above the other; these are—the Valley of Istla, 3320 feet; Mascala, 1695 feet; Popagello, 626 feet; and Peregrino, 524 feet above the sea. On the southern declivity of the plateau, which is the most irregular, the mountains appear to rise abruptly one over the other. North of Mexico, near the celebrated mines of Zimpian or El Doctor, the principal chain on the south-west assumes the name of the Sierra Madre, which, near Guanaxuato, contains the richest silver mines in the known world.

PLAN OF THE VOLCANO OF JORULLO.—This celebrated mountain, as shown in Plate 10, is situated within the volcanic series of Mexico, in lat. 19° 10′ N., long. 101° 1′ 45″ W., 75 miles S.S.W. of Valladolid, and 80 miles distant from the Pacific Ocean. The sudden upheaval of this volcanic mass in the interior of a continent, presents one of the most extraordinary physical revolutions in the history of our planet. The plain of Malpays, on which the volcano is situated, forms part of an elevated plateau, 2890 feet above the level of the sea, where, till the middle of the eighteenth century, the sugar-cane and indigo were cultivated in the fertile plains extending between the rivulets Cuitimba and San Pedro. (See plan of the Volcano.) These plains were bounded by basaltic mountains, which indicated by their structure that the whole country had been, at a remote period, the theatre of volcanic action. The fields which were watered artificially belonged to the plantation or *Hacienda* of San Juan de Jorullo, one of the richest districts of the country. In June 1759, a subterranean noise was heard, accompanied by earthquakes, which succeeded each other for fifty or sixty days. These appearances ceased at the commencement of September, when perfect tranquillity seemed to be restored; but on the night of the 28th of the same month, a subterranean concussion was again observed, and the ground called the Malpays was found to be forced up, in the form of a bladder, to an extent of from three to four square miles.[3] The borders of this space were raised 39 feet above the former plain, called the *Playas de Jorullo*, but the upheaved soil rises progressively towards the centre to an elevation of 524 feet above the sea. "The Indians who, from the summit of Aguasarco, witnessed the phenomenon, asserted that flames were observed bursting from the soil over an extent of more than half a league square, and that fragments of incandescent rocks were thrown to a great height." The Cuitimba and San Pedro were precipitated into the new volcanic vent, when the decomposition of the water contributed to revive the flames, and the eruptions of mud and beds of clay indicated that these subterranean waters contributed greatly to this extraordinary revolution. Thousands of small cones from 6 to 10 feet in height, called by the natives *Hornitos* (ovens), issued forth from the vault of the Malpays. Each cone was a fumarole, from which dense smoke ascended to a height of from 22 to 32 feet; in many of these a subterranean noise was heard, indicating, apparently, the proximity of fluid in a state of ebullition. Six volcanic masses, from 300 to 1600 feet in height, were thrown up from amid these cones, in a N.N.E. and S.S.W. direction. From the north side of Jorullo, the highest of these, lava containing fragments of other rocks was ejected in considerable quantity. Great eruptions of the central volcano continued till 1760, after which they became progressively more rare. At the time of Humboldt's visit, the subterranean fire appeared to possess but little activity, and the Malpays and the great volcano were being covered with vegetation; but the air was so heated by the action of the Hornitos, that at a distance from the surface the thermometer rose to 109° in the shade. Near the Cerro de Santa Ines, the beds of the Cuitimba and San Pedro can still be traced, and at a distance of 1½ miles west, the two rivulets are seen bursting the argillaceous crust of the Hornitos, and presenting themselves as thermal springs, with a temperature of 126° Fahr. When Mr Burkart examined Jorullo in 1827, the Hornitos had ceased to emit vapours, vegetation had made rapid progress on the flanks of the new hills, and the fields were again covered with crops of sugar-cane and indigo.

THE ISLAND OF TRINIDAD.—In the notes on Volcanic Phenomena, p. 39, mud volcanoes are mentioned in contrast with burning mountains. This island affords some interesting examples of these minor volcanoes, which, as Humboldt remarks, deserve more attention from geologists than hitherto they have received. The appearance of mud volcanoes is accompanied by earthquakes, subterranean thunders, the upheaval of large districts of country, and the eruption of flames, which rise to a considerable height, but are of short duration. The mud is usually cold, but sometimes, as in the island of Java, it is of a high temperature. The gaseous eruptions are of hydrogen, mixed with naphtha, carbonic acid gas, and nearly pure azote, or nitrogen. The island of Trinidad, extending between lat. 9° 30′, and 10° 51′ N., and long. 60° 30′ and 61° 20′ W., is evidently a section of the opposite continent of South America, from which it has probably been detached by a convulsion of nature, since the same strata of earth, the same rocks and fossils, are common to both. The northern chain of mountains, from 2000 to 3000 feet high, is a continuation of the coast cordillera of Venezuela (see the map), and, like that portion of it in the peninsula of Paria, is covered to the summit with fruit trees. The centre of the island is occupied by a series of low hills and mounds, and in the south a range of hills under 1000 feet runs parallel with the shore.

The Asphaltum or Pitch Lake of Trinidad is situated on a peninsula near Punta de la Brea, on the S.W. promontory of the island. It is about three miles in circumference, and 80 feet above the level of the sea. The headland on which it occurs consists of bituminous scoriæ, vitrified sand, and earth cemented together, and a considerable extent of the coast in its vicinity is covered with pitch, which extends into the sea, forming a bank under water. The pitch at the sides of the lake is hard and cold, but the heat gradually increases, and the pitch becomes softer, till towards the middle it boils up in a liquid state. In the many attempts that have been made to ascertain the depth of the lake, no bottom has been found; it does not appear to occupy the site of an exhausted crater, neither is the hill on which it is placed of volcanic origin, for its basis is of diluvial clay. No eruption has taken place within the memory of man, although the principle of motion still exists in the centre of the lake.

The *Mud Volcanoes* of Trinidad are situated chiefly at Punta de Icacos, the south-western extremity of the island, 40 miles distant from the Pitch Lake. They occupy a plain 4 or 5 feet above the general surface; the largest, 150 feet in diameter, is filled with boiling mud, which is constantly bubbling, but it never overflows the edges of the crater. Some of these volcanoes throw out salt water loaded with argillaceous earth. During the hottest months of the dry season the eruptions take place with a noise which is described as being like that of the loudest cannon; the mud is then thrown up to a height of at least 20 feet in the air, and the volcano cannot be approached within 50 paces.

Subterranean Volcanoes.—South of Punta de la Brea there is a gulf or vortex, which, in stormy weather, gushes up, raising the water 5 or 6 feet, and covering the surface for a considerable extent with petroleum or tar. Near Punta de Mayaro, on the eastern coast, there is another subterranean volcano, which, in March and June, gives repeated detonations resembling thunder; these are succeeded by flames and smoke, and after a few minutes, pieces of bitumen, as black and brilliant as jet, are thrown on shore. (For explanations of *the sections*, see notes on the Geology of North America, page 29.)

II. SOUTH AMERICA.

A THE PLAINS OF SOUTH AMERICA.—These comprise three principal and several subordinate divisions—1st, The Llanos or plains of the Orinoco; 2d, The forest-covered plain of the Amazon; and, 3d, The prairies or plains of the Rio de la Plata, the Atlantic slope, the Pacific slope, and the desert plains of Patagonia. The characteristics of these different plains range from the richest and most humid soil, covered by a luxuriant vegetation, through all the grades down to sterility and barrenness; and the names by which they are designated, though highly expressive, are but little understood. The word *Pampa* is used in Spanish America as the word *Campo* is in Brazil, to designate any kind of surface, not wooded, and of considerable extent; but these words with us have long had a more limited signification, since, by Pampas, we understand those connected prairies which constitute a great portion of the Argentine Republic, and are analogous to the prairies of North America. The *Llanos* of New Granada are similar to the Pampas, and a *Portero* is the name for a limited pampa. The *Pampas Geraes* of Brazil differ from the Argentine Pampas in that their surface is generally undulating, and that in them trees and shrubs are disseminated among the herbaceous plants which constitute the basis of the vegetation.

The Punas are the cold plains forming the plateaus of the Cordilleras, the elevation of which is sometimes more than 13,000 feet above the sea. The grass which covers these plains, in general almost imperceptible, forms the only nourishment of vast flocks and herds of sheep, lamas, and alpacas.

The Paramos of Equador and New Granada are only a variety of the punas, to which the epithet 'Brava' is applied, to indicate the coldness of the climate.[1] The virgin forests, called by the Spaniards *Bosques Virgines*, and by the Portuguese *Mattos Virgines*, are, in Peru and Bolivia, only met with on the eastern slopes of the great Cordillera of the Andes, or the Cordillera of the interior, which they cover almost completely above a certain height. In Brazil they occupy the hilly or undulating regions of the Atlantic slope, and they shade the basins of most of the river-courses in the interior. The name *Yungas* is in Brazil applied to the warm valleys of the eastern slope of the Cordilleras. *Sertao*, in Portuguese, means "desert," and corresponds to the Spanish *Despoblado*.

1. *The Llanos or Plains of the Orinoco* extend from the coast chain of Caracas and the snowy mountains of Merida to the delta of the Orinoco, with a branch on the south-west stretching to the mountain-knot of Suma Paz. These pampas have often erroneously been described as extending with a uniform breadth to the Strait of Magellan, overlooking the fact that the forest-covered plain of the Amazon intervenes between the steppes of the Apure and those of the Rio de la Plata. The northern plains of South America are situated within the torrid zone, and while, during one-half of the year, they are desolate sandy wastes, during the other they resemble the grassy steppes of Central Asia.[2] Their inclination or slope is directed from west to east; they are perfectly level, scarcely any part rising more than a foot above the rest. Their present level is so little above the ocean (at a distance of 450 miles from the coast the surface rises only 192 feet), as to leave little doubt that the sea once covered the whole basin, from the Parimé Mountains on the east, to those of Merida on the west.

2. *The Atlantic Slope*—the *Valleys of the Amazon*, and of the *Rio de la Plata*.—All the rivers of South America, with the exception of the few comparatively insignificant streams west of the Andes (see Plate 17), flow eastward to the Atlantic Ocean, indicating the slope of the surface in this direction, and but for the formation of the rock-bound coasts of Brazil, and the absence of bays and harbours, the Atlantic slopes of the south would rival those of North America in maritime importance; but these physical obstacles interpose, and limit its outlets to the estuaries of the Amazon and the Rio de la Plata. The valley of the Amazon is the largest river-basin in the world; it is situated partly in the northern and partly in the southern hemisphere; but although in a tropical country, its climatic conditions form a striking contrast to those of the valley of the Orinoco, for instead of being, like it, a parched desert during one-half of the year, it is copiously watered at all seasons. Its rains are mild and fertilising, and as they are not accompanied by tornadoes or hurricanes, vegetation goes on in perpetual activity. The margins of its rivers afford the richest pasture, and when cultivated, its soil produces in abundance coffee, cotton, sugar, tobacco, rye, wheat, oats, and the choicest drugs and dye-stuffs; but the vast humid regions extending between the Orinoco and the Amazon are still occupied by impenetrable forests, the growth of a thousand years. The *Valley of the Rio de la Plata* consists mostly of two immense plains, the northern forming part of El Gran Chaco and the Llanos of Manso, and the southern comprising nearly all the pampas of Buenos Ayres, a vast plain covered for the greater part with luxuriant pasturage and interspersed with salt lakes. This territory, which is equally rich in natural resources, communicates with the valley of the Amazon by its great navigable river, the Parana. But these exhaustless sources of prosperity and wealth are lost to the commerce of the world for want of a ready means of communication, and there are few movements of more importance to civilisation than that now pending, for the introduction of steam navigation on the waters of the Amazon, the La Plata, and their tributaries.

The Great Southern Plain.—The extensive plains stretching from Tierra del Fuego to the mountains of Brazil are the most barren tracts in South America. For the most part they are covered with tufts of brown grass, low bushes, and salt lakes; whilst the transition from extreme heat to extreme cold is rapid and intense. The Pampas of Buenos Ayres, during the summer, produce long, coarse, luxuriant grass, on which thousands of horses and cattle feed; and on limited spots along the banks of the Parana, and the other tributaries of the La Plata, are found tropical plants and orange groves.

The Pacific Slope is the narrow belt extending from the chain of the Andes to the Pacific shore, varying in breadth from 50 to 150 miles. In the south it comprises the moist shores and islands of Patagonia, in Chile, the fertile provinces of Talca, San Fernando, and Conception, and from latitude 10° to 30° south the rainless district of Peru (see Plate 20). Its rich and fertile plains are frequently interspersed with immense deserts of sand, termed *Arenales* by the Spaniards.

B CORDILLERA, OR GREAT CHAIN OF THE ANDES.

1. *The Andes of Equador or of Quito* extend from about lat. 5° S., to the Isthmus of Panama, 8° N., including the Cordilleras of New Granada. North from the knot of Loxa (lat. 3° 30′ S.,) which comes in between the Andes of Peru and Quito, and is celebrated for its forests of Peruvian bark trees, the chain divides into two branches, enclosing the longitudinal valley of Cuenca, and again unites in the mountain-knot of Assuay, a trachytic group, 15,500 feet high, reaching nearly to the limit of the snow line. Between the parallels of 2° 30′ and 0° 40′ S., another division takes place, the western knot, being that of Chimborazo, (21,424 feet,) and the eastern, the Peaks of Sangay, of Tunguragua, and Antisana, celebrated on account of their beautiful white cones. North from these volcanoes, between Cotopaxi on the east (18,875 feet) and the pyramidical peaks of Illiniza, the wreck of an ancient volcano (17,379 feet) on the west, lies the mountain-knot of Chisinche, a sort of narrow dyke, which forms the water-shed between the Atlantic and the Pacific Oceans; beyond this knot the chain again separates and extends to the mountain-knot of Los Pastos, on which the volcanoes of Cumbal and Chiles are situated. The volcano of Pasto, (the inhabited plateau of which is more than 10,000 feet above the level of the sea), sometimes called the Tibet of the equinoctial countries of the New World, is situated at the north of this group.

Nowhere in the Cordillera of the Andes are so many giant mountains assembled together as on the east and west of this great basin, (the classic ground of Geodesy in the eighteenth century). In the eastern chain, the snow-clad summits of Antisana, (19,137 feet) and the beautiful white cone of Cayambe, (19,617 feet,) which is traversed by the equator; and in the western, the mountains of Cotocache and Pichincha, (15,922 feet above the Pacific,) the latter celebrated on account of Messieurs Bouguer and Condamine having fixed on its summit a cross, to serve as a signal in measuring a degree of the meridian. Between these ranges lies the table-land of Quito, 200 miles in length by 30 in breadth, at an elevation of about 10,000 feet. (See map of the Table-Land on right margin of the sheet, and Geological Phenomena, plate 11, page 41.) The city of Quito, situated on the side of Pichincha, is 9543 feet above the sea, and eleven snow-capped mountains are visible from its site. During the eruption of Pichincha in 1797, the city was surrounded with lava.

North of the city of Pasto, the ridge of the Andes once more divides into two chains, enclosing the plateau of Almaguer; on the slope of the eastern of these ridges is the Cienega de Sebondoy, an alpine lake, the source of the Putumayo; and the western range is broken through by the river Patia. About the second degree of north latitude, in the group of las Papas, the crest of the Andes separates into three ranges, which do not again meet. The eastern chain of these is called Suma Paz, or the Cordillera of New Granada, which stretches in a north-east direction to the mountains of Merida, and then runs northward and joins the coast chain of Venezuela. The middle range, called the central Cordillera of New Granada, or the chain of Quindiu, runs north to the province of Antioquia. To this chain belongs the peak of Tolima, (18,020 feet in elevation), the highest point of the Andes north of the equator. The most westerly is the western Cordillera, or the chain of Choco, which extends north to the Gulf of Panama: it is of little elevation, but so steep as to render it very difficult for travellers to pass. On its western declivity is the celebrated gold and platina country, an alluvial zone from 30 to 40 miles broad. The group of Antioquia may be called a mountain-knot, because it connects the middle with the western chain.

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[1] The epithet *Brava* or *Brabo*, meaning literally savage or ferocious, as applied to inanimate objects, is constantly met with in Spanish and Portuguese America.—WADDELL, *Flore de l'Amerique du sud.*

[2] Humboldt.

[3] Humboldt, Essai Politique sur le Royaume de la Nouvelle Espagne, tome i., p. 248.

2. *The Andes of Peru,* properly speaking, extend from 15° to 5° of south latitude. The junction between the Cordillera Real and the Cordillera of the coast, occurs in lat. 14° 30′ S., at the mountain-knot of Vilcañota, 17,525 feet in elevation, and the greatest in the whole chain of the Andes.

Beyond this knot there is another double chain on the east and west of the Rio Jauja, and the plateau enclosed by these chains is about one-half less extensive than that of Bolivia. A snow-capped mountain, which is seen from Lima, called Toldo de la Nieve, belongs to the western Cordillera. In the north-west of the valley of Salcabamba, these two chains again unite in the mountain-knot of Pasco, the highest summit of which is the Nevado de la Viuda, 16,000 feet above the level of the sea, whilst the plateau from which these knots rise is more than 11,000 feet. Two small alpine lakes, Lauricocha and Chinchaecocha, in which one of the highest branches of the Amazon and the Rio Jauja originate, lie on the north and south sides of these mountain-knots. At this point the Andes divides into three chains, of which the eastern Cordillera rises between the Rio Huallaga and the Pachitea; the second or central Cordillera is situated between the Huallaga and the Upper Marañon; and the third or western Cordillera between the Upper Marañon and the coast of Truxillo.

The eastern chain stretches first N.N.E., where it is bordered by the pampas of Sacramento; it then turns N.N.W., and sinks in about lat. 5° 30′ S. North from Piscuayana, the central chain sends out two branches towards La Vellaca and San Borja, the second of which forms the celebrated pongo (waterfall) of Menseriche. The western chain, which is the highest, runs nearly parallel with the coast line, in the direction of N. 27° W. It presents, between lat. 9° and 7° 30′ S., the three high peaks of Pelagotos, Moyopata, and Huaylillas; the last is the only mountain along the whole coast north to Chimborazo, a distance of about 400 miles, that reaches the line of perpetual snow. Among these mountains are many fertile plains and populous cities: the city of Cuzco, situated at the head of a wide longitudinal valley, east of the mountain-knot of Cuzco, at an elevation of 11,400 feet, was at one time the capital of the empire of the Incas.

3. *The Andes of Bolivia* extend from about the twenty-first degree of south latitude to the fourteenth; they consist of two great mountain-chains, parallel to each other, the Cordillera of the coast, and the Eastern or Bolivian Cordillera, comprising the Cordillera Real and the Serra Carabaga, enclosing an immense alpine valley, the Plateau of Bolivia, partly occupied by the lake of Titicaca.

Mr Pentland justly remarks that, in a mountain system formed on the gigantic scale of the Andes, it is difficult to fix the geographical position of each bifurcation, and, consequently, to state with accuracy the exact parallel of latitude where the Cordillera separates into two longitudinal ridges; but the 20th degree of south latitude has generally been fixed upon as the point of separation, where the road from Atacama, and from the port of Cobija to Oruro (lat. 17° 58′), and La Paz (lat. 16° 30′), crosses the western Cordillera, near its southern extremity, at an elevation of nearly 16,000 feet. Between the parallels of 19° 20′ and 16°, the western Cordillera attains a very great elevation, and presents several snow-capped peaks, well known to navigators who sail from Cobija to Arica. The northernmost group of these peaks consists of four majestic nevados, which may be seen from the valley of the Desaguadero (see enlarged map of the Andes of Bolivia) on the one side, and from the shores of the Pacific on the other. The nevado of Gualatieri, lat. 18° 23′ S., elevation 21,960 feet; of Sahama, lat. 18° 7′, elevation 22,350 feet, the highest of the four, rises from an extensive table-land of new red sandstone, above the alpine village of Cosapa, in the form of a regular truncated cone, enveloped to its base in perpetual snow. North of Gualatieri two magnificent nevados arise, in lat. 18° 11′, known to the Creole inhabitants by the name of Melizzas, or twins, and called Pomarape and Parinacota, by the Indians. The southernmost of these forms a perfect truncated cone, from which masses of vapour are seen to issue, whilst the northernmost resembles a dome or bell. There is little reason to doubt that the latter has been formed by one great trachytic elevation. The fourth in the group, the nevado of Anaclache, is the lowest, and does not appear to exceed 18,500 feet. It forms a rugged ridge of considerable length, in the direction of the axis of the Cordillera, and appears to be also of trachytic origin.

Farther north, between the parallels of 18° and 17° 36′ S., are several snow-capped peaks, the centre of which may be fixed near the Indian hamlet of Tajora (lat. 17° 47′) and the Gualillas Pass, which attains an elevation of 14,750 feet, where it is crossed by the great commercial road from the port of Arica to La Paz and the interior of Bolivia. The nevado of Chipicani consists of a broken-down crater, with an active solfatara in its interior, emitting quantities of aqueous and acid vapours, which, by their condensation, give rise to the Rio Azufrado. The nevado of Chipicani rises to an elevation of 19,700 feet, which may be considered as the mean height of the snow-capped mountains that belong to this group. To the north of this group, the coast Cordillera is not well known; but, in lat. 16° 24′ S., three snow-capped mountains, nearly of equal height, tower over the city of Arequipa: these are Pichu-pichu, the volcano of Arequipa or Guagua-putina, and Chacani. The first and third of these mountains form two elongated serrated ridges, whilst the second presents a very regular volcanic cone, truncated at its summit, and rising to an elevation of 20,300 feet above the level of the Pacific. The three nevados of Arequipa, like most of the mountains of igneous origin in the western Cordillera, are placed near its maritime declivity; but about ten leagues from the same point, in a south-east direction, and consequently farther removed from the borders of the sea, is situated the volcano of Uvinas, now extinct, which is about 16,000 feet in elevation. On the prolongation of the western Cordillera, north of Arequipa, rise the nevados of Ambato and Corpuna; and, about twenty miles from the same city, the colossal nevado of Chuquibamba, an immense trachytic dome, which has pierced the subjacent strata of new red sandstone, and elevated itself to a height of 21,000 feet. The breadth of the coast Cordillera amounts, on an average, to nearly 100 miles. Since its highest summits are placed on the side nearest the sea, the western declivities of the Cordillera are extremely shelving and steep, so that in many places the traveller, in the course of a few hours, passes from the fruitful valleys on the shores of the Pacific to the desert regions of the Cordillera, at a height of more than 15,000 feet. On the east side of the coast Cordillera the declivity is less steep, since here it sinks into a valley itself elevated 13,000 feet, and hence, from its highest passes, the descent is only 4000 feet to reach the valley of the Desaguadero or the shores of lake Titicaca.

The eastern branch of the Cordillera, or Cordillera Real as it has been called on its northern prolongation, on account of its great elevation and grandeur, detaches itself as a separate chain south of Porco, in lat. 19° 50′. The metalliferous mountains which surround Porco may be considered as constituting its southern extremity, and the celebrated mountain, or cerro, of Potosi also belongs to it. The mean elevation of these groups does not exceed 16,000 feet, consequently none of its peaks rise within the limits of perpetual snow.

The nevado of Illimani is situated in lat. 16° 39′ S.; its form is that of a serrated ridge, elongated in the direction of the axis of the chain upon which it rises, presenting four principal peaks to the observer, when seen from its western side. From the city of La Paz,[1] distant about 25 miles, it presents the imposing grandeur of Mont Blanc. The elevation of this giant of the Bolivian Cordillera is 21,150 feet, and the lowest glaciers on its northern declivity do not descend below 16,500 feet. North of Illimani, but separated from it by the deep valley of Totoropampa and Totoral, which forms one of the most frequented communications between La Paz and the province of Yungas, celebrated for its rich plantations of coca, is situated the nevado of La Mesada (19,356), towering over the Indian hamlet of Totoropampa; and from this point (lat. 16° 30′) the Bolivian Cordillera may be said to form an almost continuous line of snowy mountains to its junction with the western Cordillera, in the mountain group of Vilcañota and the knot of Cuzco. North-west from Illimani, in lat. 15° 51′ 39″, rises the nevado de Sorata, or Ancohuma of the aborigines, above the large Indian town of the same name: it is the most elevated of all this snow-capped range, being 21,290 feet above the level of the sea. When seen from its western declivity, the Bolivian Cordillera presents a succession of sharp, rugged peaks, and serrated ridges; a configuration which contrasts with the conical and bell-shaped summits of the Cordillera of the coast, and results from their different geological conformation.

The Cordillera Real sends off to the east many lateral ridges, the most important of which is the Sierra Nevada de Cochabamba, between the parallels of lat. 22° and 17° 30′ S. This range, which has an elevation of about 17,300 feet, leaves the principal chain in about latitude 17° 30′ S.: after bounding a rich valley of the same name, to the north, it forms the water-shed between the tributaries of the Rio Beni and the Mamore, and terminates near to the town of Santa Cruz de la Sierra.

The passes which traverse the eastern Cordillera, south of Illimani, are situated at elevations not exceeding 13,500 feet. In this portion of the chain, no part descends below this level, and the rivers that rise on its western side consequently empty themselves into the Desaguadero. Arrived, however, at the snowy portion of the range, a change takes place, and the torrents which there descend from either declivity empty themselves invariably into the affluents of the Amazon; those on the west side crossing the chain of the Bolivian Cordillera; hence, the snowy Cordillera is traversed by many deep valleys, and offers many passes at elevations greatly inferior to what might, at first view, be expected from the excessive mean elevation of its highest summits. This curious fact of rivers escaping through such an immense mountain mass as the Bolivian Cordillera, is perhaps one of the most important points connected with the physical geography of this portion of the Andes. In this manner the whole of the water between Illimani and the nevado of Sorata, from the west side of the snowy range, finds its way to the affluents of the Amazon by the deep gorges through which the rivers Chuquenjo and Mapiri flow.

The longitudinal valley, bounded by the two ranges of the Bolivian Andes, with their smoking cones and serrated ridges, is remarkable, not only for its magnificent scenery, but also for its great size and extraordinary height. The existence of a table-land, the superficial area of which is calculated to exceed 16,000 geographical square miles, and of which one-fourth or one-fifth is occupied by a lake, situated 12,847 feet above the level of the sea, is undoubtedly a very remarkable geological phenomenon. The interest is further increased by the fact, that this plateau is a centre of civilisation, occupied by many rich cities and a numerous population: Potosi, said to be the highest city in the world, is situated at an elevation of about 13,350 feet on the side of a mountain celebrated for its silver-mines;[2] to the east, Chuquisaca (9350 feet), the capital of Bolivia, containing from 20,000 to 25,000 inhabitants; and, farther to the north, at an elevation of 12,226 feet, the modern city of La Paz d'Ayacucho, with a population of from 30,000 to 40,000, having the nevado of Illimani to the E.S.E. and the magnificent Sorata to the north. The lake of Titicaca occupies an area of about 2225 geographical square miles, being more than twenty-five times larger than the lake of Geneva, and is in many places more than 120 fathoms deep: it contains numerous small islands—the largest and most celebrated of which is that from which it takes its name, situated at the south-eastern extremity. The islands and the shores of this lake still exhibit monuments of ancient art—the ruined habitations and temples of a people long since perished from the face of the earth. It receives numerous streams at its northern extremity, but by no means so great a mass of water as might be expected from the height of the mountains that surround it; this arises from the water-sheds of the western Cordillera being situated near the shores of the lake, in consequence of which the greater part of its springs run towards the Pacific; while, on the eastern side, the lake is bordered by a low secondary ridge of red sandstone, which prevents the torrents descending from the eastern Cordillera reaching it, and turns them towards the Amazon.

The plateau of Bolivia, as the great longitudinal valley of Titicaca and Desaguadero may be called, is intersected by a series of detached elevations, in a direction from north-west to south-east, connecting the western with the eastern Cordillera. No part of this range reaches the limits of snow: its most elevated points, situated between Corocoro and La Plaz, and composed of new red sandstone, metalliferous porphyry, and trachyte, rise to an elevation not exceeding 16,100 feet. Mr Pentland calculates the breadth of the Bolivian Andes as follows:—

Between lat.	16°	and 17°	south,	199·5	miles.
...	17	18	...	214·5	...
...	18	19	...	266·0	...
...	19	20	...	266·0	...

But, including the lateral ridges, which rise from either side of the Andes, in the parallel of 17° 25′, in which the town of Santa Cruz de la Sierra is situated, the mountain ridges which rise from the two Cordilleras, and these two Cordilleras themselves united, occupy an extent of 500 geographical miles.

4. *The Andes of Chile* extend from latitude 21° to 42° S., running nearly parallel with the meridian, and the coast of the Pacific, in a single ridge of about thirty miles in breadth, between the latitude of Santiago, the capital of Chile, and the archipelago of Chiloe. A range of low granitic hills runs mostly parallel to the Andes, and forms the coast line of the Pacific. Between these two ranges, *i.e.* the coast ridge and the central chain of the Andes, is situated a great longitudinal valley, which forms the fairest portion of the republic of Chile—the rich provinces of Talca, San Fernando, and Conception. The southern part of this valley is filled by a chain of lakes, the remains of a great bay, which, probably, at a remote period, formed the northern continuation of that of Chonos. The Cordillera of Chile may be said to have a mean elevation of 12,000 feet, on which the jagged peaks rise at intervals to much greater elevations. In latitude 32° 29′ S., and seen from the port of Valparaiso, rises the giant of the Andes, the Peak of Aconcagua, towering over the village of that name; its absolute elevation, as deduced from Captain Beechey's observations, is not less than 23,910 feet. Behind, and rising above the capital of Chile, stands the nevado of Tupungato, 15,000 feet above the sea. Although every snowy peak has been called a volcano, it does not appear, from the most recent observations, that more than five active volcanic vents exist in the southern prolongation of the Chilean Andes—viz., the volcanoes of Maypu, Chillan, Antuco, Villa Rica, and Osorno. Under the parallel of 33° 8′, the snow line rises to 12,780 feet; seven degrees farther south, in the parallel of Valdivia, it sinks to 8300 feet; and six degrees farther north, in the parallel of Copiapo, it rises to at least 13,800 feet. On the east, various secondary mountain chains leave the central Cordillera, and extend for 300 or 400 miles into the plains, the most important of which is the Sierra de Cordova, between latitude 33° and 31° S., extending in the direction of the Pampas to longitude 62° 55′; and the Sierra de Salta and Juguy, which attains its greatest breadth under lat. 24° S., and extends gradually from the Valley of Catamarca and San Miguel del Tucuman towards the Rio Vermejo, in longitude 62° 55′.

5. *The Patagonian Andes* commence at the Strait of Magalhaens, and run north in the vicinity of the coast to about the parallel of 41° 30′ S., rising to a height of from 3000 to 8000 feet above the level of the sea. They are thickly wooded, and their precipitous summits are covered with perpetual snow, from which glaciers descend almost to the sea-shore. Among the chief of these snowy mountains are Mount Stokes, near lat. 50° S.; Melimoyu, 7400 feet high; Yanteles, 8030 feet; Corcobado, 7510; Minchinmadiva, 8000 feet; and Yate or Liebecan (lat. 41° 45′ S.) The coast between the Pacific and the base of the mountains is studded with a succession of islands or archipelagoes, covered with dense forests, and separated from each other by narrow gulfs, similar to the fiords of Norway.

C THE MOUNTAIN SYSTEM OF PARIMA OR PARIMÉ AND THE COAST CHAIN OF VENEZUELA.—*The mountain system of Parimé* extends from latitude 3° to latitude 8° N., and from the meridians of longitude 58° to 68° W., between the river Amazon and the Orinoco, the Rio Negro, and the Atlantic. The most northern chain is that of Sierra Imataca, extending south of the Orinoco, and east of the town of Angostura; it does not much exceed 1900 feet in elevation. To the south of this a chain extends from the Orinoco east to the Caroni, the highest point of which is probably near the source of the Caño de la Tortugua. The chain of Baraguan is celebrated on account of the narrows of the Orinoco, from which it takes its name. On the flat western banks of the Orinoco the peak of Uriana rises to the height of more than 3000 feet; east from this is Atures, called the chain of the Cataracts; and about twenty miles south of Atures is the chain of Quittuna or Maypures, which forms the bar of the second great cataract. The last chain to the south-west is an immense serrated wall, forming the commencement of that range of elevated mountains on the right bank of the Orinoco, which constitutes the south-western border of the mountains of Parimé. The culminating point is Duida, 7149 feet. Under latitude 4° N., the mountain chain of Pacaraima runs eastward to join the granitic table-land of Guiana. The culminating point of this chain is Roraima, 7450 feet above the level of the sea.

The coast chain of Venezuela is a continuation of the chain of Suma Paz, which extends over the Sierra de Merida, and terminates in an elevated table-land, on which the towns of Tocuyo and Barquisimeto are situated, at a height of from 1900 to 2200 feet above the level of the sea. The mountain-knot of Barquisimeto forms the eastern wall of a great circular depression, of which the Lake of Maracaybo is the centre, and which is bounded on the south and west by the mountains of Merida, Ocana, Perija, and Santa Marta. The Silla de Caracas, in the northern chain, is the culminating point not only of the system of Venezuela, but of all the mountains east of the Andes: it attains an elevation of 8600 feet. The southern chain is much lower, and its highest point, the Sierra de Guayraima, is only 7000 feet in elevation. The Sierra Nevada de Santa Marta lies between the two diverging branches of the Andes, the chain of Suma Paz, and the mountains of Panama. It rises abruptly from the middle of the plain, which extends from the Gulf of Darien to the Lake of Maracaybo: the highest part of the range, about twenty miles from the coast, and above the limits of the snow line, is upwards of 19,000 feet.

Between Demerara and Corentyn the country presents a vast extent of flat alluvial soil formed by the detritus of rivers. Along the coast of the Berbice river, savannahs extend nearly to the sea-shore. The course of this river is generally indicated by rows of trees, with here and there isolated groups like verdant islands, or oases in the middle of the desert, the surface in other places being only covered with grass. This is, unquestionably, the site of the celebrated Lake of Parimé, and the fabulous "El Dorado," the description of which forms so conspicuous an item in the history of the discovery of the New World. The banks of the Orinoco, the Rio Negro, and almost all the mountain chains of Guiana, Parimé, and Venezuela, are covered with dense impenetrable forests, and separated by extensive savannahs, generally barren in the dry season, but after the rains covered with a rich carpet of grass.

D THE MOUNTAINS OF BRAZIL.—The mountains of Brazil form an isolated group, extending at a greater or less distance from the coast, on a line from Cape St Roque to the Rio de La Plata. Their mean elevation may be reckoned at 3200 feet. The most easterly ranges, nearest the Atlantic slope, follow a uniform direction from S.S.W. to N.N.E.; more to the west the group becomes broader, but diminishes greatly in height. There is no immediate connection between the eastern and western chains, the mountains of Brazil and the Cordilleras of Peru, for a low longitudinal valley separates Brazil in the east from Alto Peru in the west, an almost imperceptible rise in the ground forming the dividing line between the rivers Madeira and Pilcomayo. Here, in ascending north from the head waters of the Paraguay to the celebrated gold and diamond region of Matto Grosso, the Pampas are diversified with groves of great beauty and extent. Villa Maria, in this province, is the centre of the great ipecacuanha region. The southern part of the chain is called Serra do Mar, or Coast Range; the northern, Serra dos Orgaõs, (Organ Mountains,) from the resemblance of its peaks to the tubes of an organ. These mountains contain more botanical treasures than any others in Brazil. They are covered to their summits by thick forests, and their sides are furrowed by thousands of streamlets, which, bounding over their granite beds, maintain the perpetual humidity of the valleys. The great chains of the interior appear to be connected, and to form a ridge whose chief direction is from east to west. This ridge commences at the Serra do Mar, and extends through the provinces of Minas, Goyaz, and Matto Grosso, forming the principal water-shed from south to north; while the Cordillera Grande, extending from north to south near the meridian of 50° W., divides the basins of the Araguay and the Tocantins. The highest chain of these mountains of the interior is situated to the north of Villa Rica (or Ouro Preto), and is connected by means of a lateral ridge with the coast range. The culminating point of this chain, and of the whole of Brazil, is the mountain Itambe, 5960 feet in elevation. South of this is the Serra da Piedade, 5830 feet; Itacolumi, 5750 feet; and the peak of Itabira, 5250 feet, which is formed of rocks of nearly pure iron.

Immediately within the coast range the Sertão or table-land of Brazil rises by several gradations to the central plateau. The Serra Mantiquiera or Espinhaço forms the first of these gradations, which extend from east to west through the whole country. The mean height of the table-land is estimated at 3200 feet. Almost the entire plateau of Brazil is occupied by *campos* (fields), the undulating surface of which is generally covered with small shrubs; but on descending from the table-land towards the great rivers, and especially to that of the Paraguay, its appearance changes, for instead of being undulating the surface is flat like the Pampas, and but little elevated above the level of the sea; so that the rivers, of which these undulations form the basins, overflow their banks at certain seasons, and form immense marshes called *pantanos.* From the summit of the plateau, which at Villa Rica or Ouro Preto is 3940 feet in elevation, it suddenly falls to half that height. It then sinks gradually in the western regions, towards the Rio Paraguay and Rio Madeira, where it terminates in low marshy plains. The sources of the Madeira, which flows north to the Amazon, and the Paraguay, which flows south to the La Plata, are only half-an-hour's distance from each other, and both are navigable for small boats to their sources. The greater part of these table-lands is covered with vast forests, not only along the banks of rivers, but also along their limiting mountain chains; and the vegetation is so dense that the country, in many places, can only be penetrated by sailing up the rivers. On this account the immense plains of the Amazon, the Madeira, and the Rio Negro, &c., are not yet so well defined as other parts of America. The soil, enriched for ages by the spoils of the forest, consists of the finest mould. The heat is suffocating in the deep and dark recesses of these primeval forests; and the damp is so excessive, that at times the whole country is enveloped in dark-blue mist.

E CHIEF GEOLOGICAL FEATURES OF AMERICA.—*Chain of the Andes.*—Granitic rocks are found in great abundance in Tierra del Fuego and in the Patagonian Andes, but are less frequently met with in other parts of the South American range. Humboldt says, a person might travel years among the Andes of Peru and Quito without finding granite, but more recent observations show that it forms the line of hills parallel to the Pacific in Chile. Quartz rock is found in great abundance in this chain, sometimes mixed with mica or gold, and containing mercury and iron. In descending towards the Pacific from Caxamarca to Guangamarca, "I have found," says Humboldt, "beds of quartz from 7000 to 8000 feet in thickness, resting sometimes on porphyry devoid of quartz, and sometimes on diorite." Porphyry occurs in great abundance over the whole range, whilst most of the higher parts of the great dome-shaped mountains are formed of trachyte. Red sandstone, with gypseous and saliferous marls, occurs in the Andes and on the table-lands. Coal is sometimes associated with it, and is found in the Andes of Pasco in Peru 14,750 feet above the sea.

The base of the Peru-Bolivian Andes is composed of silurian rocks, probably of our Devonian period, traversed by eruptions of granitic rocks: these are succeeded by red sandstone—abundant in salt, gypsum, and copper ore, covered at rare intervals with oolitic deposits. The carboniferous limestone is extremely well characterised in Bolivia by its fossils. The great metalliferous riches of Peru are situated in a species of porphyry, which may be called metalliferous, and which in many places has so volcanic an appearance as to render its distinction from igneous trachytes a matter of difficulty.

In the range of Central America, granite, gneiss, and mica slate predominate; at the same time, a great part of this chain has been upheaved by volcanic agency. In Mexico, crystalline and silurian rocks, rich in precious metals, form the substratum of the country. In the Rocky Mountains granitic and gneissic rocks, with palaeozoic strata, have been observed, but their geology is not well known. The coast chain has nearly the same character, with the addition of volcanic rocks.

The plains of Patagonia, formed into a succession of terraces, are chiefly of tertiary formation, covered with large boulders transported by icebergs from higher elevations. The pampas of Buenos Ayres are mostly formed of alluvial deposits. The mountains and the coast of Brazil abound with granite, and syenite forms the base of much of the table-land, with sandstone, clayslate, and limestone. Gold and precious stones are found in several localities. In the Parimé mountains and Venezuela the principal geological formations are granite, sandstone, limestone, and crystalline schists.

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[1] La Paz is situated on one of the highest points of the Bolivian Andes, at an elevation of 12,200 feet above the sea. Four leagues distant from the city, the most magnificent vines and figs are growing, while one league beyond, at the base of Illimani, are extensive olive groves, forming a marked contrast with the eternal snows of the mountain.

[2] Since the discovery of the mines of Potosi, it is said that 1600 [illegible] of dollars have been extracted from them. The vein of silver is understood to be as rich as ever it was, but is not worked [illegible] of mechanical power.

PLATE 8

GEOLOGICAL MAP OF THE UNITED STATES,
AND BRITISH NORTH AMERICA.

BY PROFESSOR HENRY DARWIN ROGERS, F.G.S.

The accompanying Map is designed to exhibit the more prominent geological features, as they are at present known, of that important part of North America which lies between lat. 25° and 50° N., embracing the broad territory of the United States between the Atlantic and the Pacific Oceans, together with the contiguous portions of British America on the north, and of Mexico on the south. It does not aim at picturing all the several formations properly so called, or individual rocky and earthy aggregates and strata, of separate origin and composition, which belt and spot the diversified floor of this large tract of continent, but rather at representing, in general outline, the geographical distribution of the great natural rocky groups which these constitute, so far as the best and latest investigations enable us to distinguish and classify them. In this grouping of the lesser formations into their larger natural classes, due attention has been paid to the paramount consideration of their geological age or relationships in time, as established by their organic remains, their order of super-position, and other evidences of relative date, through the researches of competent palæontological and geological observers. But accurate field investigation, guided by the requisite knowledge of structural geology and of fossils, is of comparatively recent introduction into North America, and the field itself is a very vast one, while wide tracts are only thinly populated or still in the condition of a wilderness. The explorers, moreover, have been, for so large a territory, very few, and the impediments to travel, especially in some regions, from climate, absence of roads, and the savage character of the country, have been very serious. For all these reasons it is obvious that many points in the geology of this part of the continent are still obscure. The obscurity attaches not only to the horizontal or geographical distribution of certain of the rocky masses, but to their distribution vertically—that is, to their order of super-position, or order of formation in time. In the more important cases of this uncertainty respecting the true horizontal and vertical separation of associated strata of kindred origin and age, no attempt has been made to trace upon the map the imperfectly-defined individual groups, such being generally embraced within one boundary and under one tint. This is the case with all the later igneous and volcanic rocks, the whole of which, both the trappean masses of the middle secondary periods, and the true volcanic eruptions, trachytes, lavas, and cinders of the tertiary and post-tertiary ages, being here indicated by one and the same colour—namely, an orange red. In like manner, in this, as in the Geological Map of Europe, all the crystalline strata of the gneissic and wholly metamorphic class, both the most ancient or genuine varieties of gneiss and mica slate, and the somewhat more modern micaceous, talcose, chloritic, and steatitic schists, and crystalline limestones, not readily separable at present from them, are necessarily merged together, though some of these latter belong unquestionably to the protozoic or early palæozoic ages. Again, it has been found advisable—indispensable, indeed—for faithfully representing an obvious physical feature in the geology of the country, and for exhibiting only what is at present positively ascertained, to group under one colour an extensive set of ancient non-fossiliferous semi-metamorphic rocks, although it is highly probable that at least some bands of these so-called azoic strata are the equivalents in time, if not in composition, of the two oldest of the great palæozoic formations of the country. In other cases also, as in formations of a much later age, where, from the presence of fossils and the absence of metamorphism, no such difficulty interferes with a proper analysis of the strata into their natural groups, but where simply a lack of systematic research has hitherto prevented such subdivision, it has been found expedient to represent on the map some large sequences of strata of decidedly separable ages, by a single colour. Such is the case with the great Newer Mesozoic system of strata, the equivalents of the Newer or Upper Cretaceous Group of Europe. These interesting formations, though consisting of many subdivisions, some of which are of great thickness, have been, in consequence of the immense breadth they cover, too imperfectly explored as yet to justify us in delineating them, especially in their wider western tracts, except as one mass or compound formation. It is only in New Jersey, Alabama, and Mississippi, that it is practicable at present to define on the map the line which divides the upper from the lower cretaceous deposits. These and other minuter features of the geology are reserved for a larger and more detailed Geological Map of the middle latitudes of the Continent, a work which is now in preparation.

In exhibiting the great tertiary areas of the United States a double method has been adopted, that of representing all the individual formations of whatever era, the precise ages of which are not accurately known, under a single colour, and that of separating in other parts of the map those formations whose ages and limits have been ascertained, by distinctive tints subordinate to this one general colour.

SKETCH OF THE GEOLOGY OF THE UNITED STATES.

The Geological formations of the United States comprehend both sedimentary and igneous rocks of all ages, from the earliest gneissic and granitic masses of the primordial crust to the latest depositions and eruptions of the post-tertiary and existing times. The sequence of formations is, however, not so full as in Europe, there being a few important Geological periods not represented by any strata hitherto discovered on the American Continent. This is a fact of much theoretical interest, as it implies that the crust movements were not always coincident in time, nor in the same directions, on the opposite sides of the Atlantic. While the American stratigraphical column is deficient in some members of the great series of deposits found in Europe, it is apparently more full than the European in the subordinate formations of certain great groups which the two possess in common.

The comparative geology of the two continents will be learned from the following Table, which, omitting any ultimate analysis of the rocks into formations, represents only the great natural groups, or larger series of sedimentary deposits, and gives the co-ordination of those of the two scales with each other.

Periods represented by European Strata.	American Equivalents
RECENT	Represented on a grand scale, especially in the alluvial deposits of the present rivers.
QUATERNARY	Represented by extensive terrestrial, alluvial, lacustrine, marine, and volcanic deposits.
PLEISTOCENE	Represented by terrestrial deposits, with bones of extinct mammalia, by boulder-drift, and Lawrentian marine clays and sands.
PLIOCENE	Represented by shelly sands on the Atlantic seaboard from Virginia to Texas, and by similar and other marine deposits in California.
MIOCENE	Represented by marine beds in New Jersey, Delaware, Maryland, Virginia, and Carolina, and extensively in Oregon and California.
EOCENE	Represented by extensive marine clays, sands, and limestones, along the seaboard of the Southern States; by wide fresh-water basins in the plains east of the Rocky Mountains; and by marine deposits in the Pacific slope in California.
CRETACEOUS	Diffused extensively from New Jersey to Alabama, and thence westward to the Rocky Mountains, under the form of sands, clays, marls, and soft grey limestones, and beds of the characteristic greensand.
WEALDEN	Not represented in North America.
JURASSIC	Represented in Virginia and North Carolina by a group of bituminous coal-measures, and in the valley of the Connecticut and on the Atlantic slope, from the Hudson to North Carolina; and again, in Nova Scotia and Prince Edward Island, by belts of a red shale and sandstone.
TRIASSIC	Not represented by any formations yet discovered.
PERMIAN	Not represented by any known American deposits.
CARBONIFEROUS.	Represented very extensively in the United States by coal-measures and other carboniferous strata, from the Appalachian Mountains to the Missouri River, and within, and west of, the Rocky Mountains.
DEVONIAN	Formations of Devonian date occur widely diffused and under great development, both as respects their thickness and the variety of their organic remains.
SILURIAN	Strata of Silurian age are found extensively distributed in the Appalachians and in the Western States, and likewise in the Rocky Mountains.
CAMBRIAN, OR OLDER SILURIAN.	Strata of Cambrian or Older Silurian age abound in the United States, from the Atlantic slope to the Rocky Mountains, and probably to the Pacific chain; but, like all the other older Palæozoic series, they are extensively overlaid and concealed by formations of later date.
AZOIC, OR SEMI-METAMORPHIC.	Rocks of the Azoic series, or the Semi-Crystalline Strata, next earlier in date to the first fossiliferous formations, abound in the Atlantic slope, in the Rocky Mountains, and in the Sierra Nevada, and coast-ranges of California.
HYPOZOIC, OR TRUE METAMORPHIC.	The Gneissic or ancient Metamorphic Rocks occur extensively on the Atlantic slope, especially in New England, also in the Lawrentian water-shed north of the St Lawrence and Great Lakes, and likewise in the Rocky Mountains, and in the great chain of California and Oregon.
IGNEOUS ROCKS.	The Igneous Rocks of the United States, and territories adjoining, are recent volcanic eruptions of the Volcanoes of Oregon and California and Mexico, and similar volcanic ejections of various tertiary dates; also tertiary and middle secondary basaltic and trappean emissions in great abundance on the Pacific side of the continent. Along the Atlantic slope, extensive outbursts of trap, of apparently Jurassic age, and there and in the Rocky Mountains numerous dykes and outflows of Plutonic Rocks, of all earlier periods, to the most ancient granites and greenstones, contemporaneous with the earliest Hypozoic strata.

Looking at the general features of the Geological Map of the United States, and territories adjoining, and viewing the more salient points in the geological structure of this middle portion of North America, we perceive it to consist of five great natural areas. Two of them, the largest and most irregular, include nearly all the tracts of the more ancient or Hypozoic and Palæozoic rocks, while the other three contain the chief part of the newer secondary and tertiary deposits. Of the two older areas, the more eastern embraces all that great division of the United States and the British Provinces which spreads from the Atlantic coast, and south of New York from the Atlantic plain, westward to the Missouri River, or approximately to the longitude of 97° west, and which, in a north and south direction, extends from the termination of the Appalachian chain in Alabama, and from the Washita River, in Northern Texas, to the upper limit of our Map, the territory of Hudson Bay. Throughout this extensive district, which comprises about one-half of the total breadth of the continent in these middle latitudes, there are scarcely any formations of a later geological age than the Upper Coal Measures, if we except certain relatively small strips and patches of Pleistocene tertiary bordering some of the northern lakes and rivers, and that wide and general superficial covering, the Boulder Drift, which only partially conceals the more ancient rocky strata, and which is therefore not represented by any special colour on the Map, except in the outline of its lower or southern border. The other, or more western region of the ancient rocks, includes the Rocky Mountains and their spurs, the table-land of Northern Mexico, and the whole chain of California, from the peninsula of that name to the northern and western ridges of the Sierra Nevada and the Pacific coast range. This area lies approximately between 105° and 123° of W. longitude. It is far less compact than the eastern or Atlantic region, being much subdivided by numerous and large patches of the Cretaceous strata, stretching round the Rocky Mountains into the desert plateaus west of them, and by still wider tracts of modern tertiary deposits, covering the vast arid plains and slopes of Oregon, Utah, and California, from the Wahsatch Mountains to the foot of the Sierra Nevada. This large, irregular, mountainous, and desert tract, includes rocks of all ancient epochs, from the earliest Hypozoic to the Coal formation inclusive, and abounds in igneous rocks of yet more various ages, from the earliest Plutonic injections to the latest erupted sands and ashes of recently expired or still living volcanoes.

Of the three areas of the more modern formations, chiefly Cretaceous and Tertiary, the central one, immeasurably the largest, may be defined as spreading from the southern termination of the Appalachian hills in Georgia and Alabama, westward to the table-lands of Mexico, north-westward to the eastern foot of the Sierra Nevada of California, and Cascade chain of Oregon, and northward by the broad plain of the Upper Missouri, to an undefined limit on the northern border of our Map, in the desert steppes which lie beyond that river, and east of the Rocky Mountains. The eastern and central portions of this enormous field of chiefly Cretaceous strata, the sediments of a great inland sea, now for the most part a succession of elevated sterile plains and high semi-rainless deserts, is only here and there interrupted by the protrusion through it of detached patches or island-like masses of the older rocks; but the western division of the tract, or that between the Rocky Mountains and the Sierra Nevada, is much more cut up and diversified by mountain-spurs and outstanding hills and ridges of the older formations. The scenery of this division of the continent, from the plains east of the Rocky Mountains to the great Pacific Sierra, being thus composed of extensive horizontal table-lands, deeply gashed by the passage of ancient waters, and of high protruding mountains of every variety of contour, embraces landscapes which are, perhaps, the grandest and most picturesque to be found upon the continent.

The two remaining natural geological areas are the two oceanic belts, chiefly tertiary, which fringe respectively the Atlantic and the Pacific slopes. The easternmost of these—an extension, properly, of the great central, Newer—Secondary, and Tertiary region—stretches from the southern point of the Appalachians, in a gradually contracting belt, along the Atlantic seaboard, as far to the north-east as Long Island and Martha's Vineyard. It embraces the whole of Florida, and all the lower country of Georgia, of the two Carolinas, and of Eastern Virginia, Maryland, Delaware, and Southern New Jersey. It is nowhere diversified by outbursts of igneous rocks, or the protrusion to the surface of any of the ancient formations, but is characterised throughout by the monotonous features of a low, very level plain, intersected by broad and generally tidal rivers and estuaries, and fringed along a great extent of its sea margin by extensive low swamps.

The other zone of modern or Tertiary strata, that of the narrow Pacific slope of Oregon and California, spreading from the base of the Sierra Nevada and Cascade Mountains to the shore of the Pacific, is much more diversified and interrupted in its physical features than the belt bordering the Atlantic. Consisting of sedimentary formations of geological dates corresponding to that belt, excepting that hitherto none of the Cretaceous age have been discovered in it, it has been so severely and frequently invaded by crust movements, and by actual volcanic eruptions, as to have acquired, over a large portion of its length, an excessively rugged surface and diversified structure.

With this general view of the constitution and aspect of the five great geological areas into which, for convenience of description, we have divided the part of the continent represented in the Map, we shall pass to a more detailed account of the special geology of each division.

HYPOZOIC AND AZOIC METAMORPHIC ROCKS.

Commencing our description with the oldest formations, and observing the ascending chronological order, the first two systems of rocks represented on the Geological Map are those distinguished in the key as the Metamorphic strata. This large class includes, in reality, two, and in some districts, three distinct systems of altered sedimentary rocks, all greatly metamorphosed by igneous action, and plicated and contorted in their bedding, and therefore difficult of stratigraphical analysis. These metamorphic systems or series are nevertheless distinguishable, when closely investigated, by not merely their differences of crystalline constitution, but by the great horizons of unconformable contact which separate them, amounting to breaks of parallelism both in strike and dip.

GNEISSIC ROCKS.

Description of the Rocks.—The oldest of these systems is that of the true Gneissic or most ancient Hypozoic metamorphic rocks. It consists of the highly-crystallised or true Gneiss in all its varieties—quartzose, feldspathic, micaceous, and hornblendic, with fully-developed or typical mica schist, talc schist, chlorite schist, and the other crystalline schists usually classed with the genuine or older Gneiss. Intruded among these strata are numerous veins and dykes of the true igneous or Plutonic rocks of various relative ages, but those which especially characterise this gneissic system are the Granitic and Sienitic rocks, the most ancient of the Plutonic class. Predominant above all the crystalline strata associated with it, is a massive Sienitic gneiss, or thick-bedded gneissoid rock, having in its composition an excess of feldspar and quartz. The more micaceous varieties of the true Gneiss of the United States are frequently distinguished by an abundance of the mineral garnet.

Semi-metamorphic Strata.—There probably exist more than one extensive or at least wide break in the succession of strata between the Gneissic series and the overlying Fossiliferous Palæozoic formations. Indeed, since the early years of the geological surveys of Virginia and Pennsylvania, two such have been partially recognised on the Atlantic slope in those States, and subsequently the Canadian geological survey has brought to light two horizons of discontinuity, apparently identical with these, insulating a middle metamorphic series of chloritic and epidotic schists, and highly-altered conglomerates, from the Gneissic rocks below them, and from the Palæozoic strata above. This intermediate or Azoic semi-metamorphic system of strata—recognised since 1839, east of the Blue ridge in Virginia—consists mainly, along the Atlantic slope of the Southern States, of various coarse talcoid and chloritic schists, semi-porphyritic arenaceous grits and conglomerates, and jaspery and plumbaginous slates, all penetrated extensively by veins and dykes of metalliferous, particularly gold-bearing quartz, and by dykes of porphyritic greenstone, epidote, and other older Plutonic rocks. Nevertheless, it is impossible, in the present early stage of minute field research, to define with any accuracy, over large spaces of country, the upper and the lower limits of this more or less independent semi-metamorphic system; and it is especially difficult at present to separate it from the overlying genuine Palæozoic formations, into which, indeed, this series may probably graduate in many districts without any physical break at all. The Azoic were succeeded by the Palæozoic sediments, in some quarters apparently with, in some without, the interruption of a disturbance of levels with undulation amounting to mechanical unconformity. In view of this uncertainty respecting the true limits of the older groups, no attempt has been made to indicate in the Geological Map, in the regions of the Metamorphic rocks, more than two systems—the genuine or older Gneissic, and the later or semi-metamorphic strata, the latter including both the supposed middle series, or true Azoic strata, and the proper Palæozoic formations altered in type. This merging of these two latter groups under one colour is made indispensable by the absolute impossibility of ascertaining at present the true base of the Palæozoic system, for the history of Geology forbids us to believe that research has yet detected the actual horizon of the dawn of animal and vegetable life upon our globe. The neutral tint selected to represent these Azoic and altered older Palæozoic rocks no doubt covers likewise some tracts of the genuine Hypozoic or Gneissic strata, for nowhere, even along the Atlantic slope, have all the outcrops of the latter been as yet detected, and accurately mapped. As a general rule, it will be found that the lower or non-fossiliferous Palæozoic formations occupy those parts of the semi-metamorphic belts which lie most contiguous to the zones of genuine fossiliferous strata, indicated on the map by the pale-blue tint, while the true Gneissic rocks, involved in the same general plicated tracts, occur on the side most remote from those upper boundaries, namely, for the Atlantic slope on the eastern or south-eastern margin of the semi-metamorphic belt.

Along all the northern border of the Great St Lawrence Basin, there stretches, it will be seen, from the Strait of Belleisle almost to the Missouri River, a broad irregular zone of ancient gneissic and granitic Rocks, represented in pale pink upon the Map. In this imperfectly-explored water-shed, both in certain districts in New England and elsewhere, the folds or troughs of the Gneiss undoubtedly contain many outlying remnants of Semi-metamorphic strata, some pertaining to the Azoic system, some to the Palæozoic; but no data at present exist for any definition of their local boundaries; and therefore in this portion of the Map, the pink colour must be interpreted as representing alike all the Metamorphic rocks—both those of the true Hypozoic and those of the Palæozoic classes.

Metamorphic Palæozoic Strata.—The Metamorphic and Semi-Metamorphic rocks, which are referable with the least ambiguity to the true Palæozoic system of formations, are the three lowest series or groups of that system, often greatly disguised both as respects their structure and original composition, by innumerable plications and cleavage joints, and by a pervading condition of crystallisation of their materials. The lowest group—the Primal series, so called—of the geological surveys of Pennsylvania and Virginia, extending almost the whole length of the Atlantic slope, from the Blue ridge of the Southern States to the Green Mountains, and even to Gaspé, has especially been subjected, in all its south-eastern outcrops, to thorough metamorphism. But great alteration from igneous action has extended in like manner to the two other series—the Auroral and Matinal groups, constituting with the Primal the older Palæozoic system of the country. Under their more altered type, some of the strata of the oldest or lowest of the primal slates have the aspect of semi-talcose, chloritic, and micaceous, and even hornblendic schists, with porphyritic, epidotic, and roofing slates; the Primal white sandstone has the aspect in some cases of vitreous quartz rock, in others of a stratified feldspar; the impure or earthy magnesian limestones at the passage of the Primal into the Auroral series the crystalline structure of coarse granular yellowish and white dolomite and marble, with seams and partings of crystalline scaly talc; and the Auroral blue limestone, the aspect and texture of white and mottled crystalline marble, with semi-plumbaginous laminæ; while the grey sandstone of the Matinal series has that of a highly-indurated semi-porphyritic grit, the more argillaceous Matinal shale being in the condition of indurated semi-crystalline clay-slate, partially talcose or nacreous, and intimately pervaded with cleavage. A characteristic feature in all these metamorphic deposits is a closely-plicated compressed undulation of the strata. This is seen in steep dips, which agree approximately in their direction over wide belts and even extensive tracts of country. The alternate foldings of the beds are not made about axis planes that are perpendicular, but that incline at angles of 60° or 70° to the horizon. Still farther to confuse the true order of the strata, they are generally pervaded by countless planes of cleavage, which likewise dip with the imaginary axis planes, or geometric planes, bisecting the anticlinal and synclinal folds. Throughout the Atlantic slope, in the chain of the Green Mountains of Massachusetts, Vermont, and Canada, this plication observes a remarkable constancy in its direction, the axis planes dipping, with few exceptions, towards the south-east, or the quarter of the more ancient rocks and chief igneous disturbances and dislocations of the country. These close plications, approaching to parallelism, are only the extreme local exhibition of a great general undulation, with parallel lines of elevation and depression, affecting the entire Atlantic slope and Appalachian chain in a stupendous system of waves, which everywhere progressively dilate and flatten down in a north-west direction.

In the great Pacific chain this law of close plication has not yet been wrought out in geological sections, but, judging from the universal parallelism of the dip of the strata, and its great steepness, we doubt not that a similar structure will be found to exist in those mountain ranges.

Geographical Distribution.—The Metamorphic and Semi-metamorphic strata, thus defined and explained, constitute, it will be observed, two great zones, diverging south-westward and westward respectively from the Gulf of St Lawrence. One is a coast belt, the zone of the Atlantic slope, extending from Newfoundland through Nova Scotia, New Brunswick, and the New England States, between the waters of the Atlantic and the St Lawrence, and prolonged more inland through New York, New Jersey, and the Southern States, to the end of the Appalachian hills in Georgia and Alabama. It constitutes a large irregular tract between the Atlantic Ocean and the Connecticut River in New England,—the hills of Maine and New Hampshire abounding in Plutonic rocks and minerals. The main Gneissic zone terminates at the estuary of the Hudson, but its north-western axes are prolonged across that river, forming the chain of the Hudson highlands, and, with diminished breadth and elevation, extending to the river Schuylkill in Pennsylvania. From the Delaware the great southern zone of Gneiss ranges to Baltimore, Washington, Richmond, Augusta, and onwards, maintaining its position on the south-eastern border of the Atlantic slope to Wetumpka in Alabama. Parallel belts and spurs from this main zone extend, at various intervals, to the north-west, in the middle of the Atlantic slope, but throughout the tract the typical Gneiss is subordinate in development to the crystalline schists of equivocal, though probably later age. The other more irregular belt starts from the northern coast of the St Lawrence Gulf, runs south-westward, parallel with the river of that name, to the great lakes, and then, deflecting towards the north-west, sweeps the north shores of Lake Huron and of Lake Superior, and reaches the Lake of the Woods, where one great spur of it runs off to the south-west, nearly to the Missouri River, the main zone still holding on north-westward, with a gradual northward inflection towards the Arctic coasts of the continent. The first of these we shall call the Appalachian or Atlantic Metamorphic Belt, while the other may claim the name of the Lawrentian—the Lawrentine Mountains constituting a portion of this zone of uplifted rocks. An extensive tract of hypozoic and palæozoic metamorphic rocks occupies the northern part of Wisconsin, and the adjoining part of Michigan between the Mississippi River and Lake Superior. It seems to be a spur from that portion of the Lawrentian gnessic zone which bounds Lake Superior on the north-east.

Standing out somewhat from the metamorphic region of the Atlantic slope of New England, there exists in the north-eastern angle of New York, between Lake Champlain and Lake Ontario, a broad rugged district of these older crystalline formations, surrounded on all sides by the most ancient of the fossiliferous Palæozoic strata. The district of the Adirondac Mountains stands in the forking of the two long primary zones we have been describing, and serves in a measure to unite them. It embraces both hypozoic and greatly-altered palæozoic masses. Other insulated exhibitions of the ancient metamorphic rocks occur to the west of the Mississippi, in three or more detached areas, or local igneous axes; namely, in the Ozark Mountains in the State of Missouri, in the Washita Hills west and south of the Arkansas River, and in Central Texas, on the Rio Colorado, south of the little river San-Saba. Still more detached than the last-named from the main palæozoic region of Eastern America, is that of the Witchita Mountains, which rise north of the Red River from out of the broad cretaceous plains of Northern Texas.

In the great primary region of the western half of the continent, there exist numerous tracts of the metamorphic strata, both Gneissic and altered Palæozoic, with probably others of intermediate age, containing the Granitic and other ancient Plutonic rocks, which so invariably accompany these formations. Long and important outcrops of the true gneissic strata occur throughout nearly the entire range of the Rocky Mountains, including their southern spurs in New Mexico. These rocks abound especially in the main axis of the chain which divides the head waters of the Missouri from the great Columbia of the Pacific; also in the Wind River Mountains a prolongation of the same, and in the Ceur-de-Lane range west of the main axis. They prevail likewise in the Big Horn range near the Yellowstone, and in the southern parts of the Black Hills. From the north fork of the Nebraska, to the sources of the Rio-Pecos near Santa Fé, the highest serrated crests of the Rocky Mountains, and the chief axes of nearly all the flanking ridges, exhibit, we believe, the gneissic and granitic rocks in extensive outcrops; and the same is true of the Guadaloupe, Christabelle, and other insulated ridges, which rise out of the cretaceous plains near the Rio del Norte in New Mexico and Texas. To the west of the Rocky Mountains the Gneissic rocks show themselves in some of the higher axes of the great Wahsatch range east of the Utah Desert, and in several of the ridges of the Humboldt Mountains in the centre of that vast sterile tract. On the western side of the continent these ancient strata appear at intervals extensively from the Columbia River to the Californian peninsula, especially at the eastern base and in the higher crests of the Sierra Nevada; also in the Coast Mountains, in the San Barnardino Mountains, in the chain of Lower California, in the Colorado Desert, and in the Mexican chain of Sonora. Even in the volcanic chain of the Cascade Mountains of Oregon, and in still more insulated exposures in the volcanic desert of the Columbia River, and in the tertiary country of the Pacific slope, these ubiquitous rocks peer to the surface in numerous localities.

Minerals.—In the early Gneissic series magnetic iron ore and sulphuret of iron abound. Magnetic oxide of iron is found in great veins or dykes in these districts, especially where the typical Gneiss exists in greatest preponderance, and where it has been much convulsed, as in the Adirondac Hills and the outlying spurs west of Lake Champlain, and in the Hudson highlands extending from Connecticut across New York and New Jersey, to Reading on the Schuylkill. These dykes vary in length from 100 feet to more than a mile. Some have the form of huge flattened oval columns lying obliquely between the strata, but not conforming to their dip. The chief portions of these metalliferous injections actually cut the strata, though for long spaces they may seem to conform to their bedding. The semi-metamorphic Azoic rocks are richer in metallic ores than the early Gneissic. In the Atlantic slope these ancient crystalline schists contain numerous veins of the ores of lead, copper, zinc, iron, and other metals. They form the matrix of the gold of California and the Southern Atlantic States, and of the great masses of copper ore amid the trappean outbursts on the borders of Lake Superior, which all appear to have been injected during the deposition of the earlier Palæozoic strata.

PALÆOZOIC FORMATIONS.

The Palæozoic or Ancient Secondary Formations constitute probably one-half of the total area of the United States, and the bordering possessions of Great Britain on the north. They, along with the Hypozoic rocks, underlie, indeed, so large a portion of the whole surface of North America, as to entitle this continent, in comparison with Europe, where they are very subordinate in extent of area to the later secondary and tertiary deposits, to be styled geologically the Old World rather than the New. A palæozoic sea appears to have spread itself from the hypozoic belt of the Atlantic slope, across the entire breadth of the present continent, to the Rocky and Californian Mountains, and north-westward over the region of the present basin of the Mackenzie River, even as far as the existing border of the Arctic Ocean. This we may call the Appalachian Palæozoic Basin, from the mountain chain on its south-eastern border, in which the sediments of this side of that ancient sea are so extensively and wonderfully exposed. It appears to have been separated from another Palæozoic basin occupying all the north-eastern tracts of the continent, and having apparently its centre in the great mediterranean sea of Hudson Bay, and its ancient borders in that long semicircular zone of primary or hypozoic rocks, which sweeps from Labrador, north of the St Lawrence and the Great Lawrentian Lakes, by Lake Winnipeg, Athabasca, and Great Slave Lakes, to the Arctic coast between the Coppermine and Great Fish Rivers.

Restricting our view to the southern or Appalachian palæozoic deposits, and for the present to those of the eastern half of the United States, we shall find them naturally associated or grouped by their organic remains, and the characters of their sediments, into fifteen distinct series or sets of formations, extending from the deposits which witnessed the very dawn of life upon the globe, to those which saw the close of the long American palæozoic day, or from the lowest fossiliferous strata to the uppermost beds of the coal series. These fifteen different compound formations, the accumulations of as many successive sedimentary or formative periods, are distinguished by their special physical composition and structure, and by their organic types. In the region of their thickest development, or in the Appalachian Mountains, where the whole system embraces both deep-sea and land-derived or shore-formed accumulations, the total thickness of these slowly-collected sediments, the graves of so many successive generations, is not less than 30,000 or 35,000 feet. The names we have assigned to the fifteen main Palæozoic series—those which have been employed in the geological surveys of Pennsylvania and Virginia—are terms significant of the different natural periods in which the day divides itself, from earliest dawn to latest twilight, and which are metaphorically expressive of the relative dates of production of the several formations. These periods, applicable only to the American Palæozoic day, are the Primal, Auroral, Matinal, Levant, Surgent, Scalent, Pre-Meridian, Meridian, Post-Meridian, Cadent, Vergent, Ponent, Vespertine, Umbral, and Seral, signifying the periods, respectively, of the Dawn, Daybreak, Morning, Sunrise, Ascending-Day, High-Morning, Forenoon, Noon, Afternoon, Waning-Day, Descending-Day, Sunset, Evening, Dusk, and Nightfall. A nomenclature based on time is, for many reasons, preferable to the inexpressive ones in vogue, which rest on local geographical names, or narrow and inconstant palæontological characters, and is certainly preferable to the geographical nomenclature of the European palæozoic formations, which, devised for the deposits of a wholly different ancient basin, are inapplicable to the subdivisions of the American strata, with which there is no such strict equivalency or co-ordination as to warrant their having the same appellations. The Geological Map, from its limited scale, does not, however, include the boundaries of all these fifteen Appalachian groups. Convenience in description has suggested the classification of the whole into six more comprehensive series, separated from each other by great natural horizons, which are either Physical or palæontological breaks coincident with breaks in the scale of time, and several of which are approximately coincident with the breaks which separate the leading divisions of the Palæontological system of Europe. These six several sets of formations are the products of six very dissimilar stages of formative action in the ancient Appalachian sea; in other words, they are the records of six very dissimilar conditions in the physical geography of the basin which received them. In the instance of the carboniferous formations we have been influenced by this consideration of dissimilarity of origin, and likewise by the pre-eminent scientific and economic interests attaching to the coal formation, to separate the true coal measures, deposits of strictly terrestrial sources, from the middle and early carboniferous rocks—deposits chiefly marine—upon which they rest.

These six assemblages into which we have grouped the palæozoic strata, are some of them very nearly, others only approximately, the equivalents respectively of the Cambrian or Older Silurian, Upper Silurian, Older Devonian, Newer Devonian, Older and Middle Carboniferous, and Newer Carboniferous or coal-bearing rocks. The three earliest formations, or rather series of strata—the Primal, Auroral, and Matinal—are the near representatives in geological time of the European palæozoic deposits, from the first-formed fossiliferous beds to the close of the Bala group; that is to say, they are the proximate representatives of the Cambrian series of Sedgwick. These are all pictured upon the Map under one colour, a light tint of blue. The formations of the next four periods—the Levant, Surgent, Scalent, and Pre-Meridian—are the very near representatives of the true European Silurian deposits, regarding this series as commencing with the May Hill—Upper Caradoc sandstone of England—or the horizon which separates the middle from the older palæozoic divisions. Throughout nearly every explored portion of the Appalachian or American palæozoic basin (certainly from the Atlantic slope to the Missouri River—that is, half-way across the Continent) there exists both a physical and a palæontological *break* in the succession of the strata at the contact of these two great divisions of the palæozoic system. This horizon of discontinuity in the ancient deposits, and in the assemblages of the once-living forms which they imbed, is so marked, and so general, as to make it one of the two primary planes by which the whole palæozoic system of the country arranges itself into three principal divisions. The other horizon is one of somewhat corresponding degree of sharpness, and of wide extension. It is that at the base of the carboniferous strata. Separated by these two breaks or planes of interruption into three large natural divisions, we have the entire palæozoic system, composed of a lower palæozoic division, comprising the three oldest series—the Primal, Auroral, and Matinal, a middle palæozoic series, consisting of the rocks of the nine central periods—the Levant, Surgent, Scalent, Pre-Meridian, Meridian, Post-Meridian, Cadent, Vergent, and Ponent—and a newer palæozoic division, embracing the true Carboniferous formations, of the Vespertine, Umbral, and Seral series, or coal rocks.

Between the Silurian and the Devonian equivalents there is a much less abrupt plane of separation than the one which divides the Silurian from the Cambrian; that is to say, there exists a greater relative interchange of fossils, and with it, in many districts, a closer blending of the sedimentary deposits than we discern crossing the other platform below. This causes, indeed, some ambiguity in the determination of a proper horizon for provisionally separating the Devonian from the Silurian. Guided by the general *facies* of the fossils—the Mollusca especially—the Meridian or Oriskany sandstone is regarded by some palæontologists, on the original suggestion of M. De Verneuil, as the base of the Appalachian-Devonian deposits; while other naturalists incline to begin the Devonian period at the commencement of the Post-Meridian shales and limestones which overlie or succeed that rock.

The Meridian and Post-Meridian strata—the first a coarse sandstone, characterised by very peculiar brachiopodous shells, the last a blue-and-yellow limestone, marked by distinctive fossils, most of them of Devonian, but some of them of Silurian or Ludlow types, have been grouped together, and represented on the Map under one colour—a shade of brown,—but separated from the other Devonian equivalents which overlie them, in compliance with a marked difference in their fossils. They are to be received as representing approximately the older ages of the European Devonian. The next or fourth group of formations in our scale—the uppermost of the middle palæozoic—includes the Cadent, Vergent, and Ponent series: the Cadent, a mass many hundred feet in thickness, of dark bituminous shales, with a few calcareous beds; the Vergent, a body of bluish shales and imbedded grey argillaceous sandstones, in some districts more than 3000 feet thick; and the Ponent, a still thicker mass of red shales and argillaceous red sandstones, with a few pebbly beds, having in its greatest development a thickness amounting to even 5000 feet. This group of formations, blending in its fossils the characters of the later Devonian and Carboniferous rocks of Europe, is represented by a different and darker hue of brown upon our Map.

Between this fourth group of the Appalachian formations, or the top of the middle palæozoic division, and the succeeding or carboniferous deposits, it is easy enough to trace the plane of demarcation throughout the Appalachian basin, as far west, at least, as the western disappearance of the older strata, under the overlapping cretaceous ones; but this horizon is far more clearly defined physically than palæontologically. A true break in the sequence of actions and in the scale of time, not everywhere marked by unconformity or want of parallelism of the dip, but very generally indicated in the discontinuity of the series, such as an omission of one or more of the upper formations of the underlying group, follows the base of the Vespertine, or lower carboniferous formation, throughout a very large area of the eastern half of the continent.

Yet notwithstanding this widely-extended change in the physical geography of the Appalachian sea, affecting the depth of its waters, changing the nature of its sediments, and even shoaling and draining large tracts of its previous bed, the revolution in its marine inhabitants was less complete than that which occurred where the European Devonian deposits gave place to carboniferous ones. Careful and extensive comparisons of the American middle and upper Palæozoic fossils with the European organic relics of the same periods, made by the ablest palæontologists, by Professor James Hall more especially, demonstrate beyond a doubt that, palæontologically, the carboniferous fauna commences low in the Devonian strata; and the writer of this essay has established a like early beginning to the typical terrestrial flora, deemed hitherto so characteristic of the true carboniferous strata. Defined by organic remains alone, the carboniferous formations of North America exhibit then no very clear or recognisable base; and our classification rests mainly on the suddenness of the change from marine to terrestrial forms, and on the rapid coming in for the first time of those remarkable and distinctive physical conditions of the surface, especially that amazing vegetation, and those vast humid plains, by whose agency the characteristic strata of the period, the great coal-seams, were accumulated.

Having thus indicated the general nature of the Appalachian-palæozoic deposits, our classification and nomenclature of these, the larger subdivisions of the system, and correlated these subdivisions with the great European-palæozoic series or systems, so called, we present the following more detailed but still succinct account of the composition, distribution, organic contents, and nearest place in the European scale of the formations belonging to each of the fifteen Appalachian periods, advancing as on all occasions from the older to the more modern.

PRIMAL SERIES, or Potsdam Sandstone of New York.

Description.—The Primal series, under its fullest and most diversified condition, or that which it wears in the Appalachian chain, in Pennsylvania, Virginia, and Tennessee, is a thick, fourfold group, composed of two slates and two great arenaceous rocks in alternation—(1.) The highest or Primal newer slate, is a greenish and brownish talco-argillaceous slate, sometimes very soft and shaly. In Pennsylvania it has a thickness of about 700 feet. (2.) The next, the Primal white sandstone, is a compact white and yellowish fine-grained vitreous sandstone, often containing specks of kaolin. This rock, which is of easy recognition and of an immense range, has a thickness, in some parts of the Blue ridge of Virginia, of at least 300 feet. This is the Potsdam sandstone of New York. (3.) The Primal older slate is a brown and greenish-grey sandy slate, containing much feldspathic and talcose matter. It has hitherto disclosed no fossils. The thickness of this bed, in the Atlantic slope in Pennsylvania, is several hundred feet, and in the Blue ridge of Virginia it is not less than 1200 feet. (4.) The Primal conglomerate, the lowest of the yet distinctly-recognised formations of the Primal series, is a heterogeneous conglomerate of quartzose, feldspathic, and slaty pebbles, imbedded in a talco-silicious cement. The thickness of this rock in Virginia and Tennessee, north of which it has not been discovered, is at the least 150 feet.

In New York and the North-Western States, this series presents a materially different type—the Primal white sandstone being almost the sole representative.

Thickness.—The thickness of the entire series is considerably more than 2000 feet.

Geographical Distribution.—In its geographical distribution, this Primal series ranges co-extensively, or nearly so, with the other formations of the older palæozoic division, to be presently traced: that is to say, it shows two great continuous outcrops, one stretching south-westward along the Appalachian chain, and the other westward from the St Lawrence through New York, Canada West, Northern Michigan, Wisconsin, and Minnesota, beyond the Mississippi. It is probably likewise brought to the day in the anticlinals of Missouri, Arkansas, and Texas, which elevate the gneissic strata on which it rests. Besides these, its more unequivocal exposures, this group possesses extensive outcrops in various parts of the Atlantic slope, from the British Provinces on the north-east, south-westward, to the State of Georgia. Some of these have been already, as in Pennsylvania, regularly traced and mapped. But for the most part, these eastern exhibitions of the Primal series are so disguised by metamorphism, so folded, so cleavage cut, and so crystalline, as to be very difficult of geographical limitation. While, therefore, the geologists who have explored the Atlantic slope are convinced of the presence there of large tracts of the above-described and of still inferior Primal rocks not hitherto brought into the stratigraphical column, their boundaries are not yet sufficiently known to be more than approximately represented upon the Map. A considerable portion of the long belts delineated on the Map in neutral tint as semi-metamorphic slates below the palæozoic system, both along the Atlantic Appalachian slope and in the mountain zone of California, consists undoubtedly of these Primal strata disguised by igneous action. The copper-bearing rocks of Lake Superior pertain to this series.

Fossils.—Only the two higher of the above-described Primal strata have yet revealed any fossils: the Primal or newer slate, a peculiar fucoid; and the Primal white sandstone a characteristic stem-like perpendicular form of doubtful affinities, and one or two brachiopodous molluscs, especially a lingula. In Wisconsin and other north-western localities, this formation contains several species of trilobites, and abounds in lingulæ, obolus, and an orbicula.

Equivalents.—These strata seem to be on the horizon of the lower Festiniog group or *lingula* flags of England, and equivalent to the obolus and lingula sandstone of Sweden and Russia. They represent, too, the primordial zone of Bohemia, and are therefore on the horizon of the very dawn of discovered life.

AURORAL SERIES, or Black River, and Chazy Limestone and Calciferous Sandstone of New York.

Description.—The Auroral limestone, the thickest and most widely-extended of all the Appalachian limestones, is a light-blue and bluish-grey compact limestone, usually containing, with the carbonate of lime, from 10 to 20 per cent of the carbonate of magnesia. In many parts of the great Appalachian valley, especially in Virginia, it possesses thick beds of chert. The whole mass has a thickness of not less than 2500 feet in the central part of the Appalachian chain, but it is much thinner in the North-Western States, being at several points not more than 100 feet thick.

The Auroral calciferous sandstone of New York is a coarse grey calcareous sandstone, frequently containing small drusy cavities holding crystals of quartz and of calc-spar. This is a much thinner formation than the main limestone which it supports, being in few places more than 80 or 100 feet thick. From Wisconsin westward and southward, another limestone formation, the Lead-bearing or Galena limestone of the Mississippi, is intercalated in this series. It is nearly on the parallel of the limit of the Auroral and Matinal formations.

Thickness.—The thickness of the entire series is not less than 2600 feet.

Geographical Distribution.—In its geographical distribution this calcareous group follows closely the Matinal series, with which it is in contact, extending quite as far as it to the south-west, and ranging beyond it in the region of the Upper Mississippi. It is traceable even more continuously from the valley of the St Lawrence by both its great zones of outcrop, which mark respectively the south-eastern and the northern shores of the Old Appalachian sea, than the series which overlies it. This latter has in part been washed away from certain synclinal troughs, as that of the St Lawrence, where the deeper Auroral series has been protected and preserved. The formation dipping westward from the Appalachians beneath the great coal-field just reappears in the Ohio and Tennessee great anticlinal, and shows itself again on some of the uplifts to the west of the Mississippi.

Fossils and Equivalents.—This great limestone group is less abundant in organic remains than the series which succeeds it, though it has already furnished nearly 100 species, a large proportion of which are restricted to the formation, only five or six being common to it and the Matinal rocks above. Only one or two of these species being identical with any European palæozoic forms, the group cannot strictly be said to have any European palæontological equivalent. Yet we are entitled, from its place in the system, and from the general facies of the organic remains, to place it upon the horizon of the Festiniog group, or Middle Cambrian of Sedgwick, a part of Murchison's Lower Silurian.

MATINAL SERIES, or Trenton and Hudson Group of New York.

Description.—We come now to the uppermost of the three great formations or series constituting the older or lower division of the Appalachian palæozoic rocks. The Matinal slate formation, or upper division of the series, is a very thick group of argillaceous strata, which have the form of bluish-grey shales, imbedding in their higher portion many strata of argillaceous sandstone, and even some layers of dark grey silicious conglomerate, and containing in many places, as its lowest member, a dark blue and even black carbonaceous fissile slate. In some parts of the great Appalachian valley, both in Pennsylvania and Virginia, much red and brown slate alternates with yellow shale in the central and higher parts of the formation. Near the Delaware Water Gap and elsewhere, this middle portion, much metamorphosed and intersected with cleavage plains, yields a very excellent roofing-slate. In Pennsylvania and Virginia, where this mass appears to be in greatest strength, its maximum total thickness is perhaps 2000 feet.

The Matinal limestone, the Trenton limestone of New York, the lower division of the series, is a dark-blue soft argillaceous limestone, containing interposed layers of blue calcareous shale. Many of the limestone bands are excessively fossiliferous. The thickness of this formation in Pennsylvania and New York amounts in some localities to 500 feet, though generally it is less.

These two very distinct divisions of the series maintain their independent types throughout the whole of the Appalachian chain, where the one appears to have been for countless ages the muddy bottom of a continually shoaling sea, and the other, which preceded it, the limestone bed of the same ocean, while yet it was deeper and less invaded by land-derived sediments. But tracing the formations westward, they blend imperceptibly together, until, in the great anticlinal, which brings them to the day on the Ohio River, they form one combined mass of alternating fossiliferous shales and flaggy limestones. The blue limestone formation of Ohio represents the whole series.

Thickness.—The maximum thickness of the whole series is upwards of 2500 feet.

Geographical Distribution.—This widespread formation extends the entire length of the Appalachian chain, from the estuary of the St Lawrence by the valley of Lake Champlain and the Hudson River, and thence by the same Appalachian valley, prolonged through New Jersey, Pennsylvania, Maryland, Virginia, Tennessee, into the interior of Alabama. To the north-west of this great line of outcrop it reappears in several beautiful anticlinals in the Appalachians of Pennsylvania and Virginia. On the St Lawrence, above Montreal, the main trough of the formation forks, and another outcrop starts off towards the west, ascending the St Lawrence, skirting the north shore of Lake Ontario, passing through Georgian Bay of Lake Huron, and the more northern of the Manitoulin Islands, and sweeping round the northern and western sides of Lake Michigan, through Green Bay and Winnebago Lake, and thence westward through Wisconsin, until it reaches the Mississippi River. A connecting trough unites the two main zones through the valley of the Mohawk and eastern shore of Lake Ontario, so that the gneissic and granitic mountain region of northern New York is entirely encircled by this and the other formations of the older palæozoic division. Besides these two main outcrops the series presents itself, in other more local ones, more centrally in the Appalachian basin. It appears in two large patches on the great anticlinal, which traverses Middle Ohio, Kentucky, and Tennessee, and shows itself still farther west on the Missouri, and encircling the anticlinals of the older metamorphic rocks, the Ozark mountains in Missouri, the Washita hills in Arkansas, and the San-Saba granitic hills in Central Texas. The Matinal limestone does not everywhere accompany the Matinal shale formation along their great south-eastern outcrop, but to the west of the Appalachian valley it is the more persistent rock of the two, extending into Iowa, beyond the Mississippi, and constituting, indeed, in many parts of the west, the sole representative of the Matinal series. In the large hydrographic basin of Hudson Bay, north of the Lawrentian Primary or Gneissic zone, this group of older palæozoic rocks does not reappear, but it shows itself farther westward in the palæozoic basin between Lake Winnipeg and the Rocky Mountains, especially on its eastern side.

Fossils.—Both the formations of this series are rich in organic remains, some of which are common to the two strata, but the greater number restricted to their own deposits. It is remarkable that very few, probably not three per cent, are common to these formations, and to any of the strata which overlie them. The highest organisms hitherto found in these widely-extended rocks are some trilobites, cephalopods, and molluscs; no fishes, nor remains of any vertebrate animals, having ever been detected.

European Equivalents.—The nearest British representatives of these Matinal strata seem clearly to be the Llandeilo and Bala rocks, Lower Silurian of Murchison, or Upper Cambrian group of Sedgwick; the Orthoceratite limestone of Sweden and Russia representing them in Northern Europe.

LEVANT SERIES, or Medina Group of New York.

Description.—Succeeding the Matinal, and preceding the Surgent in order of time, is another triple formation, here called the Levant series. The upper member of this consists of white and light-grey fine-grained hard sandstone, alternating near its upper limit with beds of red and greenish shale, the sandstone covered with peculiar fucoids in great profusion. This division, in Pennsylvania, measures between 400 and 500 feet. The middle member is a soft argillaceous brown sandstone and red shale. Its greatest development is in the mountains which cross the Juniata River, where its thickness is from 500 to 700 feet. The third, or lower member, is a hard greenish-grey massive sandstone, embracing in its eastern outcrops, as in the Kittatinny and Shawungunk Mountains, thick beds of silicious conglomerate, made up chiefly of the wreck of the previously formed and disturbed older palæozoic rocks. This division varies in thickness, in Pennsylvania, from 200 to 400 feet. The uppermost and middle of these is the Medina sandstone of the New York Survey.

Thickness.—The maximum thickness of the whole series is about 1500 feet.

Geographical Distribution.—Tracing them in their geographical distribution, the Levant rocks follow the outcrop of the Surgent series, next to be indicated, westward to Lake Michigan, and south-westward, along the Appalachian chain. But in the latter direction, the Levant white sandstone prolongs itself beyond the termination of the Surgent shales, displaying itself in great force in the Clinch Mountain of Tennessee, and other Appalachian ridges, as far as Alabama. The Levant red shale, or middle member, is in full dimensions on the Niagara River, and crosses the peninsula of Canada West. Some of these rocks occur in the Green Mountain chain, and nearer the Atlantic, in the State of Maine, and Province of New Brunswick.

Fossils.—Very few organic remains occur in this group, but those which do are characteristic. The chief marine forms are shells, conspicuous among which is a *lingula*. But more instructive still are the strange fucoids, forms of an ancient marine vegetation, which invariably accompany the upper strata.

European Equivalents.—The Mayhill sandstone, or upper Caradoc, the terminal or lower member of the Wenlock group of England, seems to be on the parallel of this Appalachian Levant series, which is therefore the equivalent of the base of the European Silurian system, if we accept Professor Sedgwick's classification, or the Upper Silurian, if we embrace Murchison's. That it is the base of the American middle palæozoic formations, appears from many considerations, physical and palæontological. The conglomerates mark an ancient shore at a period of great disturbance and uplift of the earlier palæozoic strata, which was accompanied by a total change in the organic forms.

SURGENT SERIES, or Clinton Group of New York.

Description.—The next natural group of strata, ascending, the Surgent series of the Pennsylvania Survey, or Clinton group of the New York, is a diversified formation, composed, when fully expanded, of three groups—an upper one, consisting of variegated red marls or calcareous shales; a middle one of an alternation of shales and argillaceous fossiliferous limestones and calcareous sandstones, with one or two remarkable seams of fossiliferous iron ore; and a lower group, composed of greenish and yellowish fissile slates, weathering olive and claret coloured, including in their central part beds of red, very ponderous, ferruginous sandstone, usually containing two or three thin layers, sufficiently rich in the peroxide of iron to be extensively available as an iron ore.

Fossils and Equivalents.—The more calcareous middle member abounds in organic remains, shells, corals, echinoderms, trilobites, &c., all of them of forms significant of an equivalency in age to the Wenlock and other formations at the base of the Upper Silurian series of Europe.

Geographical Distribution.—This series exhibits its maximum thickness and complexity in the central parts of the Appalachian chain in Pennsylvania, gradually diminishing south-westward through Virginia to Eastern Tennessee, where it seems to expire. Traced westward, it crosses New York from the neighbourhood of the Helderberg Mountains to the Niagara River; thence sweeps north-westward across Canada West to the Manitoulin Islands of Lake Huron; thence westward, by Mackinaw, by the north shore of Lake Michigan, to Green Bay, and southward, down the Lake Coast in Wisconsin, where it appears to thin out, no part of the formation having been discovered to cross the Mississippi. This northern outcrop, in ranging thus towards the west, displays, what so many of the other formations exhibit, a gradual change from a shore to a mid-sea type, the shales and sandstones becoming progressively less in volume, and the limestone relatively augmenting. A bed of limestone, and another of calcareous shale, are all that represent it on the Niagara River; and in Wisconsin it is composed of little else than a thin stratum of fossiliferous limestone, which is there in contact with the Niagara limestone, with which it has been confounded. It is barely traceable on the borders of the dome-shaped anticlinal of the older palæozoic rocks in Southern Ohio and Northern Kentucky, and does not appear in that of Middle Tennessee. In the north-eastern part of the Atlantic slope and Appalachian chain, the formation presents itself in some outcrops in the Green Mountains, and in the basin south of them in New Brunswick and the State of Maine, but under a less expanded type than that which it assumes in Pennsylvania and New York.

Thickness.—On the Juniata river, in Pennsylvania, the whole series has a thickness approaching 2400 feet, which is probably its maximum in the country.

SCALENT SERIES, or Onondago Salt and Niagara Limestone Groups of New York.

Description.—The series next in order consists strictly of two formations, the upper one a group of gypseous marls and shales, the lower one a compact limestone surmounting grey calcareous shales. The gypseous marls, or Onondago salt group of New York, is a mass of grey or ash-coloured calcareous shale, alternating in its upper part with beds of argillaceous and silicious limestone, some layers of which are curiously pitted with small angular cavities, the nests of solitary crystals of sulphate of lime and carbonate of strontia. Gypsum abounds in this formation, both diffused and in thin seams, and near the surface in large insulated lenticular masses or cakes.

Geographical Distribution.—The stratum is imperfectly represented in the Appalachian chain south-west of New York; but it ranges through that State, through Canada West, and through the Western and Northern States almost as far as the Mississippi.

Equivalent.—This formation appears to possess no true equivalent among the rocks of Europe. But as the Scalent limestone below it, and the Pre-Meridian limestone above it, are both on the parallel of the Wenlock group of Great Britain, it is obvious that it belongs to the Wenlock period.

Description.—The other or lower division of the series, the Scalent limestone—the Niagara limestone of New York—is a double formation of limestone and shale, consisting, in its upper division, of a sparry very compact grey limestone, some bands of which are extremely fossiliferous. In its lower portion it is a bluish calcareous shale, somewhat pyritous, and containing a few fossils. The great difference in the susceptibility to erosion of these two strata is the cause of the remarkable terrace and cataract of the Niagara River.

Thickness.—The thickness of the Niagara limestone gradually augments from east to west. Its maximum is in the region of the Mississippi, being there, it is believed, nearly 1000 feet.

Geographical Distribution.—It ranges westward from near the Hudson. The formation traverses the lake peninsula of Canada West, the northern and western shores of Lake Michigan, the southern part of Wisconsin, and northern part of Illinois, the whole breadth of Iowa, and only disappears where it is overlapped near the Missouri by the western cretaceous deposits. It rises in the Ohio anticlinal, at the Falls of the Ohio, and appears in Kentucky and Tennessee. It has but little development anywhere in the Appalachian Mountains.

Equivalent.—The Scalent series is on the parallel of the Wenlock formations of Great Britain.

PRE-MERIDIAN SERIES, or Lower Helderberg Limestone of New York.

Description.—The formation which holds the next position in the ascending order is a somewhat diversified limestone formation, consisting usually, in its lower portion, of shales and thin flaggy layers of limestone; in its middle member, of a fossiliferous and sometimes sparry compact grey and blue limestone, containing layers and nodules of chert; and in its upper division, of a dark ash-coloured calcareous sandy shale.

Geographical Distribution.—In the Appalachian chain this rock ranges from near the Hudson south-westward to Tennessee. Its northern outcrop stretches from the same neighbourhood to the Niagara River; but it is only the lower member or water-lime which extends thus far, the middle and upper expiring within 100 miles west of the River Hudson.

Thickness.—The thickness of the entire formation seldom exceeds 300 feet, and throughout long tracks the rock is very thin.

Fossils and Equivalents.—These marine limestones and shales abound in characteristic organic remains, many of them generically and even specifically identical with the shells, corals, trilobites, and other fossils distinctive of the Wenlock formation of Great Britain, evidently their nearest equivalent in the European system. No remains of fishes, nor vestiges of any vertebrate animal, have ever been discovered either in this formation or in any of the strata beneath it. It may be regarded as the uppermost deposit of the Silurian ages in the Appalachian sea.

MERIDIAN SERIES, or Oriskany Sandstone of New York.

Description.—This is a remarkable arenaceous formation, interposed between the Post-Meridian and Pre-Meridian limestones. The upper member of the series, a rock of rather restricted range in New York and New Jersey, is a calcareous and argillaceous thin-bedded sandstone or grit, characterised in its lower layers by a peculiar fucoid, resembling somewhat a cock's tail. Its thickness, on the Delaware River in New Jersey, is about 300 feet. The sandstone, the principal member—called in the New York Survey the Oriskany sandstone—is a coarse yellowish calcareous sandstone, graduating near its upper limit into a fine-grained quartzose conglomerate, and becoming in its lower beds a coarse arenaceous limestone.

Fossils.—Its distinctive fossils are large brachiopodous bivalves.

Thickness.—The greatest thickness of this rock in New York and Pennsylvania is less than 200 feet.

Geographical Distribution.—This formation ranges through the Appalachian chain, is exposed in many outcrops from New York to Eastern Tennessee, and extends westward from near the Hudson through New York, a distance of about 300 miles. There is no special equivalent for this stratum among the formations of Europe, though its nearest place in the scale of strata is probably that of the lower Ludlow rocks of England.

POST-MERIDIAN SERIES, or Upper Helderberg Limestone of New York.

Description.—Beneath the Cadent older black slate there lies, throughout the Northern States, from near the Hudson, westward through New York, New Jersey, Pennsylvania, Ohio, Upper Canada, Michigan, Indiana, Illinois, Kentucky, Missouri, and Iowa, a widely-expanded marine limestone, the Upper Helderberg, or Corniferous and Onondaga limestone of New York. In Canada and the Western States it is a straw-coloured and light-grey rock, often sparry and sometimes oolitic. It is the upper part of the cliff limestone of the West. In its more eastern exposures it is generally bluish. It contains nodular chert.

Fossils.—This rock contains many fossils, and some beds of it consist almost entirely of corals and shells, and it is evidently the product of an immensely extended coral reef. It is the lowest American formation in which there are any remains of fishes: these are large ganoid species, resembling those of the European Devonian rocks.

Thickness.—Its maximum thickness, which is in the Western States, is about 350 feet; but its average depth does not exceed one-third of this.

Equivalents.—The nearest European representative of this rock is the English Ludlow formation; but it contains numerous Devonian fossils, and even some Carboniferous ones. It is therefore not exclusively a Silurian equivalent. The occurrence of productus and pentramites shows that even carboniferous races tenanted the waters of the Appalachian sea of the Post-Meridian period.

CADENT SERIES, or Genessee, Hamilton, and Marcellus Groups of New York.

Geographical Distribution.—These Cadent strata have their greatest development in the valleys of the Appalachian chain in Pennsylvania and Virginia. Like so many of the other shore-formed deposits of this part of the Appalachian sea, they manifest a gradual reduction of thickness in the south-west direction, becoming much attenuated before they reach Eastern Tennessee, but, unlike others, one member at least of the series stretches to the west and north-west over an enormous distance. The black slate of the Western States shows a continuous outcrop the whole way westward across New York to Lake Erie, and thence southward across Ohio and Kentucky to the anticlinal of Middle Tennessee, which it everywhere fringes. It encompasses, on the east, in like manner, the wide basin of carboniferous strata encircling the Indiana and Illinois coal-field, and, in another belt, crosses the peninsula of Michigan, from the lake of that name to Lake Huron. It seems to thin away by the time it reaches the Kankakee River, on the northern edge of the Illinois coal-field, and in a more southern latitude in the neighbourhood of the Tennessee River. Rocks of this age are believed to occur in a narrow outcrop bordering the carboniferous basin of New Brunswick.

Fossils.—The Cadent strata are the oldest American formations in which remains of a true terrestrial vegetation have as yet been discovered. Besides these, which are rare, they contain numerous species of mollusca and other marine forms, several of which are identical with European Devonian and Carboniferous species, many being found in no other rock. Goniatites and other carboniferous genera characterise the Cadent black slate both in Pennsylvania and the Western States.

Description.—This series, like the succeeding, has its greatest expansion in the Appalachian chain and in Southern New York, and declines steadily in thickness in spreading into the Western States. From New York to Eastern Tennessee it is a group of three formations. The upper or later, the Cadent newer black slate (Genessee slate of New York), is a brownish black, and in some regions a bluish black very fissile slate, characterised by numerous small and delicate molluscs, chiefly of Devonian, but some of them of Carboniferous genera, and likewise by remains of a true terrestrial vegetation, generically identical with that of the coal-measures. This rock has a thickness, in some parts of Pennsylvania, of 300 feet. The middle member or formation, the Cadent shales, the Hamilton group of New York, is a bluish grey, brownish and olive-coloured clay shale, with thin beds of dark grey sandstone, sometimes calcareous. It abounds in fossils, especially bivalve shells and corals. Its greatest thickness in Pennsylvania is about 600 feet. The lowest or Cadent older black slate (Marcellus shale of New York), is a black and highly bituminous slate, graduating upwards into a dark-blue argillaceous shale, surmounted, in some districts, by greenish sandy shales. A thin argillaceous limestone generally occurs near the bottom of the black slate in Pennsylvania, Virginia, and Tennessee. The fossils of the formation are some of them identical with those of the Cadent newer black slate. Many of them are diminutive, and some minute vegetable forms are possibly terrestrial. In Pennsylvania the thickest exposures of this member of the formation measure nearly 300 feet.

Thickness.—The entire Cadent series is about 1200 feet thick.

These Cadent strata are represented in the Western States, from Southern Ohio both south-westward and north-westward, by only one rock, a fissile black slate, which may represent either the upper or lower Cadent formations, but which is generally regarded as the Cadent newer black slate, or Genessee slate of New York. Reposing immediately upon the Post-Meridian limestones, and surmounted in turn by the Vergent strata, and west of the Ohio anticlinal by the Older Carboniferous or Vespertine, and having a very extensive distribution, it constitutes an important stratigraphical horizon. If this black slate be the oldest of the Cadent rocks, the absence of the others establishes an extensive hiatus between it and the Vergent. If, on the other hand, it represents the Cadent newer black slate, a like hiatus exists in the absence of the middle and lower Cadent formations.

Equivalents.—The nearest equivalent of these Cadent strata among the European formations would appear to be the Older Devonian rocks of the Eifel, but, as presently to be intimated of the Vergent, these Cadent strata all contain some carboniferous forms.

VERGENT SERIES, or Chemung and Portage Groups of New York.

Description.—This formation is in two divisions, the upper called, in the New York Survey, the Chemung Group, a thick mass of grey, blue, and olive-coloured shales, and grey and brown sandstones, the sandstones predominating in the upper part, and the shales abounding in fossils, especially brachiopoda. The lower division, the Portage group of New York, consists of a rather fine-grained grey sandstone, in thin layers or flags, parted by thin bands of soft blue shale. Its characteristic fossils are fucoids, or ancient sea-weeds.

Thickness.—On the Juniata River, in Pennsylvania, the upper rock has a thickness of 3200 feet, while that of the lower amounts to 1700.

Geographical Distribution.—These strata extend south-westward as far as Tennessee, and probably Alabama, and westward to Ohio, Kentucky, and Middle Tennessee. But their equivalents, if they have any farther west in the Appalachian palæozoic basin, have not been ascertained.

Equivalents.—A comparison of their organic remains teaches us that these strata are most nearly represented in Europe by the Eifel strata of the Devonian series. They possess several true Carboniferous species.

PONENT SERIES, or Catskill Group of New York.

Description.—In its fullest development, viz. in Pennsylvania and New York, this is a thick mass of alternating red shales, and red and grey argillaceous sandstones, some of which, in the upper strata, are sparsely sprinkled with white quartz pebbles.

Geographical Distribution.—This rock steadily declines in thickness towards the west, and thins down entirely upon reaching the Alleghany River. South-westward, it extends in several interrupted outcrops along the Appalachian chain as far as Eastern Tennessee, but under a gradually declining thickness. It is absent throughout all the Western States, and even along the western outcrop in the Appalachian coal-field on the Alleghany River, and south-westward. Nowhere throughout the Western States has any true equivalent or representative of it been discovered; and we are forced to the conclusion, therefore, that a movement of the bed of the Appalachian sea took place at the close of the middle palæozoic periods, preventing a deposition of Ponent strata, and causing here a break in the sedimentary succession, or scale of geological time.

Thickness.—The maximum thickness of the Ponent beds in Eastern Pennsylvania is not less than 5000 feet, and they thin to nothing in a distance of 200 miles.

Fossils and Equivalents.—Few organic remains exist in this formation; but those few, such as the *Holoptychius*, are eminently distinctive of the age of the European Devonian, especially of the Old Red Sandstone of Great Britain. No remains nor footprints of reptiles have ever been discovered in the Ponent strata.

VESPERTINE SERIES, or Lower Carboniferous Strata.

Geographical Distribution.—The Vespertine, or Lower Carboniferous series, has apparently a much less extensive distribution westward, from its eastern outcrops in the Appalachian chain, than the Umbral series which rests upon it. From the district of its maximum development around the anthracite coal basins of Pennsylvania, we trace it with a rapidly-diminishing bulk north-westward, until it thins away altogether upon reaching the Alleghany River. Upon the north-western border of the great Appalachian coal-field it has no existence whatever; but it ranges south-westward from the anthracite country to a far greater distance, following especially the eastern margin of the general coal-field, maintaining more nearly its thickness across Virginia and Tennessee. Passing beneath the Cumberland Mountain and its spurs in Alabama, this stratum takes on, like so many others, a less littoral or sandstone type for a more marine or limestone one, and emerging to the day once more in central Kentucky and Tennessee, it begins to assume the characters of a fossiliferous, sandy, and argillaceous limestone. Under this form it underlies the Umbral limestone in Indiana and Western Kentucky, and on the Mississippi and Missouri rivers. In its western outcrops the stratum is apparently much thinner than the purer limestone group above. How far it spreads to the west of the Mississippi River has not yet been ascertained. Possibly this formation, and not the Umbral limestone, is the equivalent of the lower Carboniferous group, or gypseous red sandstone of Nova Scotia and Cape Breton. In the absence of more distinctive proofs of equivalency from organic remains, we are entitled to infer that the lower carboniferous strata of the Provinces represent both the Umbral and the Vespertine rocks of the Appalachian basin.

Description.—In its south-eastern outcrops in Pennsylvania and Virginia, this series is a thick mass of white, grey, and yellow sandstones, alternating with coarse silicious conglomerates, and dark-blue and olive-coloured slates. In some localities it includes beds of black carbonaceous slate, and one or more thin beds of coal.

Fossils.—Where it has its eastern or ancient shore type, the only organic remains are fragments of coal plants, for the most part specifically different from those of the upper or true coal-measures. In the Western States, it abounds in crinoids and molluscs. To the north-west of the Appalachian chain, in Northern Pennsylvania and Ohio, this formation grows more argillaceous, and gradually thins away; and on the south-western outcrop of the great Appalachian coal-field in Kentucky and Tennessee, and in its outcrops circling the great western coal-fields, the whole mass exhibits a more marine type, its material being chiefly a fossiliferous limestone, filled with oceanic forms, and a grey and yellow sandstone. In the Western States this rock is called the sub-carboniferous limestone.

Thickness.—In Pennsylvania its maximum thickness exceeds 2000 feet.

Equivalents.—This formation belongs to the same period, apparently, as the carboniferous slates of Ireland, or the lowest carboniferous rocks of Europe.

UMBRAL SERIES, or Middle Carboniferous Strata.

Description.—Along the Appalachian chain, this series, in its fullest development, is a triple group, the lowest members consisting of buff, greenish, and red shales, with some sandstone; the middle of a thick mass of light-blue limestone, sometimes oolitic; and the upper of blue, olive, and red calcareous shales, containing massive strata of grey and brownish sandstone. This is the type in Virginia. In Pennsylvania the whole stratum consists of soft red shales and argillaceous red sandstones. In the Western States the principal formations are a light-blue and yellowish limestone, replete in marine organisms, and a grey and yellow sandstone.

Geographical Distribution.—Tracing the Umbral series through its principal outcrops, we find it bordering the several coal-fields of the Eastern British Provinces, under the type of a very diversified group of red shales and sandstones, with conglomerates, calcareous and gypseous marls, and thick beds of limestone, and layers of gypsum; the whole having a maximum thickness of about 6000 feet. Entering the true Appalachian region, we meet the Umbral red shale first in Pennsylvania, and trace it with a gradually declining thickness from its maximum of 3000 feet on the Schuylkill, southward to the borders of Maryland, where it becomes more calcareous and variegated and fossiliferous, and receives as a middle member the Carboniferous Limestone. Advancing in this direction, the limestone gradually augments in thickness, while the upper and lower groups of shale as gradually thin down. But far to the south-west, on the Green Briar River of Virginia, each of the three divisions has a thickness exceeding 1000 feet. The northern outcrop, on the other hand, consisting alone of the red shale and sandstone, grows rapidly thinner as it ranges westward under the successive anthracite and semi-bituminous coal basins of Pennsylvania, thinning away entirely at the sources of the west branch of the Susquehanna. The Umbral or carboniferous limestone, if followed as a single formation, first shows its extremely attenuated feathered edge on the Alleghany Mountain, at the sources of the Conemaugh in Pennsylvania. Thence, augmenting southward, as already said, through Maryland and Pennsylvania, it ranges in great force, though in a narrow outcrop, along the south-eastern border of the great coal-field through the latter State, Virginia, Eastern Tennessee, and Northern Alabama, to the termination of the mountains. This rock does not exist at the western margin of the Appalachian coal-field anywhere in Northern Pennsylvania, or in Ohio; but when we enter Kentucky it gradually develops itself between the Seral and Vespertine strata, and soon becomes a conspicuous formation in the western escarpment of the Cumberland Mountain, the whole way across Kentucky, Tennessee, and Northern Alabama, expanding widely to the westward in the latter State.

Passing to the other carboniferous districts farther west, this limestone, divided from the broad intervening region, reappears first to the north in a slender outcrop, encircling the southern half of the coal-field of central Michigan. Leaping a second wide interval, it again shows itself, enclosing the whole of the great coal-field of Illinois, Indiana, and Western Kentucky. There it is comparatively thin at its northern outcrop, but along the eastern margin of the coal-field it gradually thickens, and widens its area as it advances southward, until, on the Ohio River, and round the southern side of the basin, it acquires a great development. We may next trace it along the south-western and western borders of this coal-field, from the Ohio River along both sides of the Mississippi, past the mouth of the Missouri, and skirting the upper Mississippi as far north as the Red Cedar River of Iowa, near which the anticlinal belt divides, one outcrop turning eastward round the Illinois coal-field, the other westward to enclose that of Iowa. From the Mississippi River, between the Ohio and the Missouri, it spreads largely through Southern Missouri, encircling the wide elliptical anticlinal district of the Ozark Mountains, and older palæozoic rocks at their base. On the western side of the great western coal-field of Iowa, Missouri, and Arkansas, this formation once more emerges from under the coal strata, and spreads over a wide belt from their western border to the eastern margin of the unconformably overlying cretaceous deposits of the plains of Nebraska and Kansas. Thickest towards the south, this great marine stratum covers almost continuously the wide district which separates the southern termination of the Appalachian coal-field in North Alabama, from the southern border of the Illinois coal-field in Western Kentucky. Throughout the whole broad area over which we have thus far traced this rock, we witness a thinning-off in a north-eastward direction. While its thickness, on its southern and south-western outcrops, is in several places from 1000 to 1200 feet, it is no more than 300 feet in Iowa,—is much less than this in Northern Illinois, and fines away entirely, in passing under the Michigan coal-field, from its attenuated western outcrop; and we have seen that in Ohio and Pennsylvania it has no existence.

This widely-diffused formation is not restricted to the eastern palæozoic region of the continent, but exists largely developed in the other more insulated ancient tracts of the western side. It occurs in the Rocky Mountains, and in many of the isolated ridges of New Mexico, in which that great chain dies down, and it has been met with extensively in several of the mountain systems still farther west, as in the Wahsatch chain of Utah, in the Humboldt Mountains of the Salt Desert, extensively on the Rio Gila, and in the table-lands of Sonora; and it has been detected even in the Sierra Nevada of California. The pale-bluish tint adopted for this formation alone throughout the eastern half of the Map, is intended in the western part of the sheet to express the presence of palæozoic strata generally, for quite too little is at present known of the Rocky Mountains and the country west of them, to permit there that detailed separation of the palæozoic system, which was practicable, and desirable, for the Appalachian basin east of the central prairies.

Thickness.—The maximum thickness of the whole series in Pennsylvania and Virginia is about 3000 feet. In the Western States the limestone exceeds 1000 feet.

Fossils.—Everywhere the fossils are generically identical with those of the great carboniferous limestone of Europe. The Umbral red shale of Pennsylvania contains almost no animal remains, and very few vegetable. It does, however, present, on some of the ancient shore-surfaces, beautifully-distinct footprints of ichthyoid reptiles, and trails of brachiopodous molluscs, and also impressions of a few peculiar aquatic plants. The Umbral limestone, and the variegated shales into which the red shale graduates towards the south-west, abound, on the contrary, in organic remains, corals, crinoidea, brachiopods, and other molluscs. In Nova Scotia the marine beds likewise contain remains of ganoid fishes.

SERAL SERIES, or Coal-Measures.

Description.—The coal-measures of the United States and the north-eastern British Provinces consist of argillaceous and silicious sandstones and quartzose conglomerates, of clay shales of nearly every colour and texture, of fire-clays and coal-slates, of argillaceous limestones, chiefly of marine origin, and of numerous seams of coal. This coal-bearing group is underlaid throughout nearly all the coal-fields of the country, from Pennsylvania to Alabama and Missouri, by a coarse silicious conglomerate or millstone grit, which also in some localities contains thin seams of poor coal.

Geographical Distribution.—The eastern half of the continent contains five great coal-fields, distributed at intervals from Newfoundland to Arkansas. 1. The first, or most eastern, is that of the eastern British provinces—Newfoundland, Nova Scotia, and Cape Breton, and New Brunswick—originally a wide coal-field broken into patches by uplifts of the older strata, and by the waters of the St Lawrence Gulf. The surface, covered by the coal-measure of the Provinces, is probably about 9000 square miles, but apparently only one-tenth of this area is productive in coal. 2. The second, which I have called elsewhere the great Appalachian coal-field, commences in Pennsylvania, and extends south-westward to near Tuscaloosa in Alabama. This includes several outlying lesser basins—those, for example, of anthracite coal in Eastern Pennsylvania. It has a total area of about 70,000 square miles. 3. The third is the smaller coal-field of the centre of Michigan, equidistant from Lake Huron and Lake Michigan. The area of this may be given at about 15,000 square miles. It is very lean in coal. 4. The fourth is the great coal-field lying between the Ohio and Mississippi anticlinals, and spreading in the form of a wide elliptical flat basin, from Kentucky northwards through Indiana and Illinois, to Rock River. This possesses an estimated area of 50,000 square miles. 5. The fifth, and most western, is a long and large coal-field occupying the centre of the great basin of carboniferous rocks, which spreads from the Mississippi and Ozark anticlinals westward to the visible limit of the palæozoic region, where it is overlapped by the cretaceous deposits of the prairies. The northern limit of this coal-field is in Iowa, on the Iowa River; the southern is near the Red River, on the western confines of Arkansas; and the total area of the great irregular basin is not less than 57,000 square miles. In a south-westerly direction from the southern point of this last coal-field, are three or more small detached patches of coal-bearing strata, surrounded by the superficial cretaceous deposits. These are probably only the denuded outcrops of one long subterranean basin, prolonged from the main one through Western Arkansas and Northern Texas. Besides these chief areas of coal belonging to the eastern half of the continent, there would seem to be some localities of this substance bordering the Rocky Mountains, and in the region of the Wahsatch chain of Utah. But so many of the reputed cases of coal discovered in the interior of the continent have proved, upon a geological scrutiny, to be deposits of lignite of cretaceous and even tertiary age, that we are cautious, in the present imperfect stage of the evidence, about assigning any of these to the true carboniferous formation.

Summing up the several areas here defined, we perceive that the broad coal-fields of North America occupy the enormous space of at least 200,000 square miles, or more than twenty times as large a surface as that which includes all the known coal deposits of Europe, or probably of the eastern continent.

Thickness.—Comparative measurements of the thickness of these several deposits of the American coal-measures, indicate a marked reduction from the east towards the west. Those of the Nova Scotia field, as measured at the South Joggins, Bay of Fundy, show a thickness of nearly 3000 feet; those of the south-eastern anthracite basin of Pennsylvania an average thickness about as great; while the central portion of the great Appalachian bituminous basin has a depth not exceeding 2500 feet. Those, again, of the Illinois basin are probably not thicker than 1500 feet; while the last, the Iowa and Missouri basin, is evidently much shallower, its total depth not surpassing probably 1000 feet.

In Nova Scotia, the coal-fields contain, in the Joggins section, in all about fifty seams of coal, only five of which, however, are of workable dimensions: these are equivalent to about 20 feet of coal. In the deepest anthracite basin of Pennsylvania, that of the Schuylkill, there are, where the formation is thickest, about fifty seams in all; but twenty-five of these have a diameter exceeding 3 feet, and are available for mining. In the great Appalachian coal-field there appear to be about twenty beds in all, and ten of these are of workable size. Again, in the broad basin of Indiana and Illinois, the total number seems not to exceed ten or twelve, and it is believed that only seven of these are of a size and quality suitable for mining. Only two or three such are believed to exist in the shallow and much-denuded basin of Michigan. Still farther west, the coal-fields of Iowa and Missouri contain, it is believed, only three or four beds thick enough to be profitable, while the total number of seams of all sizes is probably not more than six or seven.

Fossils.—The organic remains of the American coal strata belong to the same forms of vegetation which are typical of the coal rocks of other countries. Many of the species, however, are local or peculiar. The strata of marine origin contain corals, shells, and remains of fishes; while others formed at the sea-level show the imprints of shore reptiles and molluscs.

European Equivalency.—It is obvious, from the very general accordance between the fossils of the American and the European coal strata, that the former were produced during the age of the upper or main coal-measures of the European carboniferous series.

MESOZOIC FORMATIONS, or Middle Secondary Strata.

Older Mesozoic.—It is remarkable that while the middle latitudes of North America contain very extensive districts of Palæozoic strata, and others almost as wide of the Newer Mesozoic or Cretaceous, and extensive regions of Tertiary or Cainozoic deposits, the Continent embraces an extremely small extent of the Older Mesozoic or Triassic and Jurassic formations. Up to the present time none of these latter have been discovered anywhere to the westward of the Atlantic slope; neither at the base of the Rocky Mountains, where, from considerations of physical geography, we might expect to find them, nor between the palæozoic and tertiary rocks of the Pacific slope in Oregon and California. Even along the Atlantic slope these strata exist in narrow detached belts of comparatively restricted length, in situations which indicate that they were accumulated in local estuaries and small basins, and not upon the general oceanic border of the land as it then existed.

Two independent formations or groups of strata of very nearly the same geological age comprise all the older Mesozoic deposits of the country hitherto ascertained. Possibly the oldest and certainly the most extensive of these is a Red Shale and Sandstone group, distributed in a series of detached basins from Prince Edward's Island in the Gulf of St Lawrence to the Atlantic slope of North Carolina. The other, a Coal formation of very limited area, occurs in three or four small and narrow basins in Eastern Virginia and North Carolina, between the Potomac and Roanoke rivers, immediately west of the western margin of the Atlantic tertiary deposits.

Mesozoic Red Sandstone.—Notwithstanding their insulated position with respect to each other, the several masses of middle secondary red sandstone exhibit a remarkable general agreement as regards their composition. Argillaceous red sandstone, red shale sometimes slightly calcareous, grey carbonaceous shales in small amount, and coarse silicious and other conglomerates, are the prevailing sedimentary rocks. Very generally, especially in that which extends continuously from the Hudson to the James River in Virginia, the whole deposit consists of three members, the lowest being a conglomerate formed of pebbles of the adjacent older strata, imbedded in a cement of red shale; the middle, an extensive alternation of red shale and argillaceous red sandstone; and the upper, often absent, and always of moderate thickness, another conglomerate similar in composition and in origin to the lowest.

That portion of the formation which occupies the southern half of the valley of the Connecticut River consists chiefly of argillaceous sandstone, with beds of red silicious conglomerate and some partial layers of grey carbonaceous shale; but, on the whole, is much less shaly or argillaceous than the belt which traverses the middle States.

Those patches of the deposit which cover Prince Edward Island and the shores of Cobequid Bay in Nova Scotia, differ chiefly from the others in containing more calcareous cement in the soft red sandstones. The principal strata are coarse red sandstone, coarse heterogeneous conglomerates in the lower part, and soft calcareous red shales.

Geographical Distribution.—Commencing at the north-east, the first tract of Triassic or Jurassic red sandstone is that which skirts the northern shore of Chaleurs Bay in New Brunswick from the neighbourhood of Gaspé Bay south-westward.

The next area is Prince Edward Island, almost the whole of which consists of a red sandstone, which some geologists refer to this formation. A third tract is the deposit already referred to as lining the shore of Cobequid Bay or eastern head of Minas Basin in Nova Scotia. This reaches only as far east as Truro.

In the United States we meet with the next belt in the valley of the Connecticut, where the rock covers an area nearly 135 miles long, by from 7 to 10 miles wide, extending from near the northern line of Massachusetts southward to Long Island Sound.

The largest belt of all, or that of the middle and southern States, stretches from the west bank of the Hudson River, where it is upon the level of the ocean, inland in a south-westerly direction along the south-eastern side of the South Mountain and Blue Ridge, gradually contracting in breadth and ascending in level through the States of New Jersey, Pennsylvania, Maryland, and Virginia, to near the centre of the latter, where it terminates.

Another narrow strip of the same rocks runs from a little north of the Roanoke River south-westward almost to the Yadkin in North Carolina; and between the main belt and this one, there occurs a small patch on the James River, in a position which indicates that originally they were all three connected. Some miles to the eastward of this principal belt, there is another still smaller patch on Willis River, a tributary of the James, which, with one or two other still more trivial outlying masses, implies that there has been an extensive denudation of the original shallow deposit.

The most southern tract hitherto brought to light lies to the south-east and south of the Roanoke belt, and extends from the Tar River, North Carolina, south-westward, almost to the Wateree River of that State. This belt passes a few miles to the west of the city of Raleigh.

Organic Remains and Geological Age.—None of the deposits of the middle secondary or new red sandstone formation of the Atlantic border abound in fossils, but the vestiges of organic life which they do contain are remarkable. These consist of plants, chiefly terrestrial, of two or three shells, and simple crustaceæ, of several fishes, chiefly species of the genus *Catopteris*, of two or three *Thecodontoid Saurians*, and of the footprints of some twelve or fifteen species of quadrupedal animals believed to be reptiles, and of the tracks of between thirty and forty varieties of birds.

The red rocks of Prince Edward Island pertain probably to both the coal period and to that of the other red sandstones farther south, or the earliest Jurassic; some of these strata on the south side of the island imbedding what seem to be carboniferous plants, while others, on the northern side, have yielded a fossil reptile, the *Bathygnathus borealis*, the affinities of which point to a middle secondary epoch. No fossils have been discovered as yet in the Nova Scotian middle secondary basin; but as it evidently lies unconformably in a trough of the carboniferous and other palæozoic rocks, formed at the close of the coal period, we have the same evidence for its post-carboniferous age which was formerly accepted before the discovery of any fossils in the red sandstone of New Jersey and Pennsylvania, as a sufficient proof of the middle secondary date of that deposit. But besides this stratigraphical fact, there are many circumstances of close identity to connect this formation with those of the great middle secondary estuaries of Connecticut and the Atlantic slope. Chief among these is a close correspondence in the nature of the sedimentary materials, washings into shallow bays of the soils of the adjacent older rocks; and secondly, a remarkable analogy in all the phenomena of the trappean rocks which contain native copper and its ores, and which penetrate alike these several formations. These trappean outbursts, closely linked in time with the strata which they penetrate, are so alike in lithological constitution, in the minerals which they enclose, and in the constant presence of copper, especially in the native state, that we are compelled to regard them as the products of one period—the eruptions, indeed, of one crisis in the disturbances of the Atlantic front of the continent.

The vegetable fossils in the Connecticut sandstone, consisting chiefly of *Cycadites*, *Lycopodites*, a few ferns, and equisetaceæ, display such alliances with those of the Jurassic coal rocks of Eastern Virginia as to place the early Jurassic or late Triassic age of the deposit beyond a question.

The fossil fishes of the Connecticut, once referred to the genus *Palæoniscus*, but since to a separate genus by Redfield and Sir P. Edgerton, have less heterocercal tails than that palæozoic family, and plainly indicate a middle secondary age. These fossils, occurring both in the Connecticut and the New Jersey deposits, serve to identify these two formations in time, while the occurrence of other species very nearly of the same type in the Liassic coal rocks of Eastern Virginia, supplies a further link to associate these latter with the several different red sandstone formations which we are describing. Redfield has called this genus Catopteris; the name Ischypterus has been proposed for it by Sir Philip Edgerton. But the most interesting of all the organic remains in the Connecticut red sandstone are the quadruped and biped footprints above referred to. The former, it is believed, were left by different species of lizards, turtles, and frog-like or batrachian reptiles; the latter by various species of wading-birds, some of them of very colossal size. Coprolites, or specimens of the dung of these creatures, have also been occasionally met with. The tracks occur at intervals throughout a distance of more than eighty miles from Turner's Falls in Massachusetts southward, and are repeated on successive surfaces through a thickness of more than 1000 feet of strata, measuring this by the usual rule of the dip. This, as will presently appear, does not, however, necessarily prove a subsidence of the bed of the red sandstone estuary through so great a space. No actual remains of birds, recognised as such, have hitherto been brought to light; though a few obscure bones, believed to be reptilian, have, it is said, been discovered. As the bird tracks here spoken of are the earliest vestiges yet met with in any country of this high class of creatures, an especial interest attaches to the determination of the true age of the rocks, of an antiquity so remote, which contain them.

Of the fossils of the middle secondary belt of the middle and southern States, one of the most significant is a small crustacean form, a *Posidonia* very similar to the *P. minuta* of the European Trias, but believed to be a different species. This occurs associated with countless multitudes of two minute species of *cypris*, another small crustacean. They are met with abundantly in the thinly laminated carbonaceous shales of the formation in the interior of Virginia, and as far to the north-east as the Schuylkill River in Pennsylvania. Being indicative of fresh waters, their presence is expressive of an ancient river flowing into a tidal estuary, debouching where the Hudson now opens towards the sea. Coprolites, probably reptilian, occur with them near the Schuylkill. Still farther to the north-east, but towards the upper or north-western margin of the formation, near Morristown, and near Pompton, New Jersey, the remains of fishes and a few bird-tracks have been found, identifying, as already stated, this deposit with that of the Connecticut. Besides these, the actual bones and teeth of a saurian reptile (*Clepsysaurus Pennsylvaniensis*) have been recovered from the upper beds of these red sandstones in Lehigh Co. Pennsylvania.

Dip of the Red Sandstone, and Physical Conditions attending its Origin.—Some of the features of bedding of the middle secondary red sandstones are sufficiently remarkable to claim special mention here. In Prince Edward Island, and in the Nova Scotia basin, the stratigraphical conditions are not peculiar, the rocks in the first-named district being disposed in low and broad undulations, but with a prevailing dip to the north-east, and those in the latter having the form of a regular trough, one side or outcrop reposing with a north-west dip on the palæozoic rocks of the south side of the Bay of Fundy and basin of Minas; the other side with a south-east dip, skirting the southern base of the Cobequid Mountains, and fringing the north shore of the same waters. But in the deposit of the Connecticut valley, and that of the middle and Southern States, the stratification is decidedly abnormal. Throughout the former there prevails only one direction of the dip, which is a little to the south of east, the average inclination being about 20°, though in some places it is as low as 7° or 10°, and in other places as steep as 40° and 50°. What renders this prevalence of one dip the more remarkable is the absence of any external marks of great faults or dislocations, or of any repetition of the same strata on a section transverse to the strike, the whole formation appearing to be one unbroken sequence of deposits. Over a large part of the tract the beds seem to hold, indeed, the very attitudes or inclinations under which they were formed, though, in certain localities, especially towards the western margin, and adjacent to the larger outbursts of trap rock, they seem to have been uplifted, or laterally squeezed into steeper inclinations than originally belonged to them.

Throughout the great southern belt, from the Hudson to Virginia, a similar phenomenon of the dip presents itself under circumstances still more striking. Without exception the strata dip in only one direction, but they descend towards the north and north-west, and not, as in the Connecticut valley, towards the east. In each instance they dip from one shore towards the opposite, across the entire breadth of the basin or estuary which originally received them. In this longer tract the prevailing slope is 15° or 20°, and it nowhere exceeds about 30°. Everything in the constitution of these strata in both belts—their materials, the direction of their dip, and their oblique bedding—indicate that they were deposited slopingly from one side only of their respective estuaries; and we may see, in the positions of the respective water-sheds which fed them, the features of the physical geography which caused this mode of origin. In the case of the Connecticut estuary we have merely to suppose that its greatest depth or its channel was near its eastern shore, and that it was fed by lateral rivers descending eastward from the water-shed of metamorphic strata which even now divides the plain of the Connecticut from that of the Hudson River. In the other instance, we find, in the existing physical and geological structure of the two borders of this great estuary, an equally ready explanation of the monoclinal dip and the origin of the materials. The bold features of the mountain chain which formed the north-west shore of this great bay and river imply that its deepest channel lay close upon that side, and in the talcose and other metamorphic rocks of the region bordering the estuary on the south-east, which even at this day are remarkable for the red soils they produce, we see the source from whence the materials were derived. The obliquity of the original deposition of the red shales and sandstones is not a matter of hypothesis, but a necessary inference from observed facts of superposition; for in some places, several miles to the north of the southern border of the belt in Pennsylvania, where, measured by the ordinary trigonometrical rule which assumes that the strata were originally horizontal, and were afterwards uplifted, the thickness of the deposit should be many thousand feet, we discover it to be extremely shallow, denudation having cut entirely through it, and exposed the older system of rocks which constitute its floor.

Interpreting, then, from facts presented, the physical conditions which attended the beginning, progress, and close of these middle secondary deposits, we are entitled to assert that their period was ushered in by a sudden agitation of the region resulting in an abrupt depression of the tidal portions of each tract below the general ocean level; or, in other words, in the creation of broad and shallow river-valleys running longitudinally with the mountains, and opening to the sea. Into these newly-created depressions the suddenly-displaced drainage of the bordering tracts would sweep in a load of fragmentary matter for the production of those conglomerates which almost everywhere constitute the lower strata of the formation. After the first convulsions were over, a permanent drainage, in the one case from the west, in the other from the south-east and south, would supply the softer and finer materials of the great body of the deposit. The oblique deposition of these materials would result, from their lateral introduction and the scouring action of a strong tidal or river current, in the channel, sweeping out all sedimentary matter from the middle and far side of the estuary, and permitting only that to collect which was piled forward layer upon layer by the muddy tributary streams, frequently swollen by rains.

If, in connection with these views of the physical geography of the period, we people the borders of each estuary with the wading-birds and water-frequenting reptiles whose vestiges are impressed upon the once soft strata, and admit the natural assumption that the tracts in which they delighted were the tidal portions of these estuaries, we may readily conceive how the footprints of these animals were buried up and preserved. At each recession of the tide they would go down to feed upon the last newly-deposited silts of the sloping shore, and retiring, leave their footmarks, and each returning or flood tide backing the turbid waters descending from the hills would throw down a fresh layer of sediment to fill these imprints, and preserve them unaltered for an indefinite time.

To account for the very heterogeneous conglomerates which constitute the uppermost or final stratum in so many localities, it is merely necessary to consider what would take place at the first coming on of that series of volcanic actions which produced the great dykes and outflows of trappean lava that occur so extensively in all these middle secondary belts. These conglomerates consist almost exclusively of the fragments, imperfectly rounded, of the older rocks of the immediately adjoining hills, imbedded in a paste of the red shaly matter of the waters of the estuary; and it is a significant fact that they include no pebbles of the trappean rocks. The eruption of the traps was therefore posterior to the formation of the conglomerates. Let us, then, suppose that just prior to the actual eruption of the igneous rocks, these middle secondary tracts were violently convulsed and partially or even entirely uplifted by vehement earthquakes, and we have at once a sufficient cause for the formation of the conglomerates and the drainage of the basins. The waters of those estuaries containing these terminal breccias must have been lashed violently against the base of the steep bordering hills. In their agitation they would tear off, partially round, and strew the fragmentary materials within their reach, imbedding these in the paste of sand and mud with which they were already charged. The draining-off of the estuary waters towards the side of the ancient channel would naturally produce that oblique dip of the conglomerates under which they seem to have been formed, and by which they abut against the rocks of whose fragments they consist. Further and still more energetic convulsions, with uprising, would complete the desiccation of those tracts which became permanently dry, and result in that extensive rupturing of the crust which gave birth to the dykes and the plateaus of trap rock that now so extensively intersect these deposits. In certain cases the entire length of each middle secondary belt seems not to have been uplifted to the sea-level before the commencement of the trappean eruptions; and those tracts which remained thus submerged are seen to contain, interstratified, as it were, with the later sedimentary deposits, those sandy volcanic tuffs or subaqueous sedimentary forms of trappean matter which constitute the link between the exclusively aqueous and igneous masses. These aqueo-plutonic rocks or trap shales abound more in the not yet entirely uplifted basin of Nova Scotia, but they occur to some extent in the lower or more oceanic parts of the other two great estuary tracts—that of the Connecticut River, and that of the Middle States.

Trap Rocks.—The igneous rocks of these middle secondary belts of the Atlantic sea-board constitute one of the remarkable features in the geology of the country. With very few exceptions, they are restricted to the limits of the red sandstone deposits, there being obviously some law of connection between their geographical distribution and that of the rocks which they invade. For the most part they occur in great dykes and ridges, ranging longitudinally with the strike of the strata they intersect, or approximately parallel with the borders of the middle secondary basin. They are of all dimensions, from ridges and even plateaus many miles in length and several hundred feet in altitude, to short and narrow dykes of the length of a few hundred feet and width of a few feet or inches. Some of them are approximately straight, but by far the greater number show a curved or crescent shape, and some of them even are hooked at their ends until their points range at right angles to their main portions. With a few exceptions the ends or horns of these crescent-shaped dykes and ridges point in the direction of the dip of the red sandstone strata which they intersect; and this law of their direction is not confined to the great middle secondary deposit of the Middle States, but prevails quite as conspicuously in that of the valley of the Connecticut. What makes this the more striking is, that as the strata in these two estuary-deposits dip towards nearly contrary quarters—in the former towards the north-west, in the latter towards the east—the points of the trappean ridges in the two instances observe corresponding differences of direction. This remarkable relation of the form of the dykes to the dip of the strata enclosing them, has its solution apparently in the fact that the trappean matter was extruded partly up the previously established slopes of the obliquely deposited red sandstone, and partly perpendicularly through the transverse breaks in the strata occasioned by the stretching of the crust, and the lifting, as on a hinge, of the outcrop part of the strata borne up by the rising trap.

These rocks consist for the most part of coarsely-crystallised greenstone trap and dykes of more compact basalt. Sometimes the rock is a true dolorite; amygdaloidal or vesicular traps and toadstone are not unfrequent; and the trap shale or sedimentary aqueo-plutonic variety is also, as already stated, met with.

Of the minerals associated with the trap, the most distinctive are metallic copper and its ores, especially the red oxide of copper, green carbonate, and grey sulphuret; but these do not occur in regular lodes. Specular iron ore, in small tabular crystals, is also common, and magnetic iron ore. All these are most apt to occur next the outer walls of the dykes, or in the fissures of the sedimentary rocks immediately contiguous. Many attempts have been made to mine the copper at a profit, but hitherto invariably without success. Other characteristic minerals are—agates, stilbite, laumonite, chabazite, analcime, phernite, epidote, and occasionally datholite, and others.

Metalliferous Veins.—In two or three districts true metalliferous lodes occur within the limits of the middle secondary red sandstones. And in one locality—that of Montgomery and Chester counties, Pennsylvania—some of these veins have been experimentally mined, and with partial success. These veins are not associated with dykes of trap rock, but are independent metalliferous injections, consisting of some of the ores of lead, zinc, and copper, involved in various gangstones, quartz, feldspar, oxide of iron, &c. The chief ores are sulphuret and phosphate of lead, carbonate and sulphate of copper, and the sulphuret and carbonate of zinc. The Wheatly lode, the most promising of this group, penetrates both the gneissic rocks and the red sandstones. It has already furnished nearly thirty mineral species; among these, some rare crystalline combinations or salts of the metals above named.

Jurassic Coal Formation.—The Jurassic coal formation, apparently identical in age, or nearly so, with the Jurassic or middle secondary red sandstone, occupies a much more restricted area than that other rock on the Atlantic slope. It is limited, indeed, to a series of small basins, at intervals, along the eastern border of the great zone of metamorphic strata, a little west of the western boundary of the tide-water tertiary plain, from the Potomac to near the Wateree River, in South Carolina. One strip stretches from the west bank of the Potomac, some miles south of Washington, in a narrow interrupted outcrop, as far as the James or Powhattan River, obscured for the most part, except where it is intersected by the Chesapeake Rivers, by the overlapping lower beds of the Eocene and Miocene tertiaries. This long narrow zone consists chiefly of a soft pebbly cohering whitish-grey argillaceous sandstone, in which the cementing material of the sand is frequently a white kaolin. Though it contains numerous fragments of an oolitic vegetation, it appears to possess no regular seams of coal. Its position and composition indicate it to have been formed on a line of coast rather than in an estuary.

The next patch, a genuine coal basin, occurs on a line a little west of the above described, and seems to have been originally more inland. It extends from a few miles north of the James River to the southern side of the Appamattocks River to a length of about 25 miles, with a mean width of 8 or 10 miles, the centre of the trough lying about 12 miles west of the city of Richmond.

The materials of which this coal basin consists are principally coarse grey micaceous sandstone, with comparatively little true shale or slate, and they seem to have been derived from the subjacent granitoid gneiss, upon which they immediately repose, in a wide deep trough. These coal-measures have been penetrated on their eastern margin, by mining, to a depth of nearly 900 feet, and a section across the basin shows that they probably have a total thickness in the centre of 1500 or 2000 feet. Only the very lowest portion of the formation is productive in coal: the two, and sometimes three, distinct known seams being all comprised between the lowest, 150 feet. One of these beds, the very lowest, is in some places of enormous size, being as much as 30 feet or even 40 feet thick. It is very variable, however, being in other spots not more than 4 or 5 feet, and appears to have been formed in hollows on an irregular floor of the older rocks, for the bottom of the seam is in some places within a few feet, or even inches, of the gneiss. The coal is a highly bituminous fusible gas-making variety of the species called cherry coal, of a low specific gravity, and a brown streak or powder. The mines are wet and deep, and are not prosecuted with much activity, the total yield of the basin in 1854 being about 150,000 tons.

Fossil Vegetable and Animal Remains.—These coal-bearing strata contain several interesting species of extinct plants, some or all of which have evidently contributed to the beds of peat out of which the coal-seams were derived; but none of them pertain to the vegetable forms found in the ancient carboniferous strata, or true coal-measures. Nothing like the old Stigmaria, Sigillaria, or Lepidodendron, nor any species of the numerous herbaceous and tree ferns of the older coal has been seen. The distinctive forms are—*zamites*, *calamites*, and *equisetums*, with a noble fern, *tæniopteris*, and one or two species of *pecopteris*. Several of these forms appear to be identical with the well-known fossils of the lower oolitic sandstones of Yorkshire. It is probable that the carbonaceous matter of the coal was largely derived from the fleshy cellular stems of the gigantic zamias.

Of the animal remains, the most significant relics yet discovered are a few teeth, which seem to have belonged to some saurian, and numerous specimens of two or three genera of very slightly heterocercal fishes, one of which is the liassic genus *Tetragonolepis*, and one, a new genus, has been called by Sir Charles Lyell *Dictyopygi*. True mollusca are rare; but a shell-like form, the *Posidonia* or *Possidonomia*, once before spoken of, and recently suspected to belong to the crustacean genus *Estheria*, is occasionally found, and is one of the interesting fossil links which connect this oolitic coal-formation with the adjacent Jurassic red sandstones.

Like the red sandstone basins, this coal-field seems to have been invaded at the date of its elevation by great crust disturbances, lifting it from the water, faulting its rocks, and injecting it with dykes of trap. Some of these trappean dykes appear not to have reached the surface, for they lose themselves between the strata; and in one remarkable case, the igneous rock, traversing or rather resting on one of the coal seams, has converted it by slow heat and pressure into a natural coke of a dull lustre and great compactness. It is not a true anthracite, but a real coke; and it is doubtful if anthracite on the large scale has ever been produced from bituminous coal through the contact or proximity of igneous rocks merely. The coal-field of Eastern Virginia is excessively fiery, and many disastrous explosions have arisen in the mines from the copiousness of the fire-damp.

The coal-field of Eastern Virginia would appear to have been, at the date of its formation, a fresh-water swamp at the head of a bay penetrating the land from the north, and it is probable that the non-coal-bearing sandstones of the same age in the belts adjoining were deposited on the western coast of this bay, or the main shore of the continent just outside of it.

Oolitic Basin, North Carolina.—The third, principal, and by far largest tract of the Jurassic coal-formation, occurs in North Carolina, extending from the Tar River, in a somewhat irregular belt, south-westward, a distance of 150 miles, to Lynche's Creek, or possibly the Wateree River, in the north-eastern corner of South Carolina. Of the geology of this belt less is at present known than of the Virginia ones. The rocks are chiefly argillaceous sandstones, and on the Deep River of North Carolina they contain one or two thin seams of bituminous coal. The principal, and apparently only valuable coal-bed, has nowhere, it is believed, a thickness of more than 4 feet; but it has been detected at intervals along an outcrop of twelve miles, and possibly, therefore, it may one day become of commercial importance. It occurs near the eastern side of the formation, dipping, with all the rocks yet examined, gently to the westward; but its opposite dip has never been discovered, and it is not yet ascertained that the strata themselves have the trough-like form, though the occurrence of a continuous seam of coal, which can only have originated when at least its own part of the formation was horizontal, is evidence of a more or less extensive uplifting or basining movement.

Fossils.—The few organic remains hitherto procured from this Carolina coal-field are identical with forms found either in the Virginia Jurassic coal strata, or in the Virginia middle secondary red sandstone, of nearly coincident Jurassic date. They are chiefly two or three coal plants, and the characteristic animal remains, *posidonia* and *cypris*. We know too little yet of the stratification of the district to infer the physical conditions which attended the production of this middle secondary formation.

NEWER MESOZOIC.

Cretaceous Deposits.—One of the most widely-expanded of all the groups of strata in the United States is the cretaceous. Unlike the corresponding series in Europe, it embraces no formation of genuine chalk, though in the south-west and far west it includes important strata of limestone. Along the Atlantic sea-board, and as far as the Mississippi, the chief materials are, beds of sand and sandy clay, with thin layers of argillaceous limestone or calcareous shale, but the arenaceous character generally predominates. A characteristic constituent, especially in the north-eastern portion of the Atlantic belt, is green sand or green earth in an arenaceous or granular form—this material existing in thick deposits of 20 or 30 feet deep in the lower part of the formation in New Jersey and Delaware. In these States the whole series comprises five separate beds, which, in the ascending order, are:—

I. A group of sands and clays, some of which are extremely pure and white, affording excellent potter's clay.

II. A mixed alternating group of beds of dark-blue sandy clay, with beds of nearly pure greensand, uncemented or arenaceous, which, being endowed with highly fertilising qualities, is ordinarily called the greensand marl.

III. A thin bed, seldom more than a few feet thick, of a porous yellowish or straw-coloured limestone, frequently silicious, and always containing scattered specks of greensand.

IV. A very ferruginous, coarse, yellowish sand, occasionally containing a small amount of a green mineral. This is generally an uncohering deposit, but near the Raritan Bay some of its layers possess the cohesion of a soft sandstone.

V. A coarse brown ferruginous sandstone, sometimes passing into a conglomerate, forming the fifth and apparently uppermost member of the group. This likewise contains the greensand in minute granules.

The total thickness of the series here described cannot be less than a thousand feet, for it occupies in New Jersey an outcrop several miles in width, with few or no perceptible undulations. Throughout its southern development, in Georgia, Alabama, Mississippi, and Arkansas, the cretaceous series preserves its general arenaceous type, though it is more calcareous than in New Jersey, some of the calcareo-argillaceous beds resembling the European Lias. Advancing westward through Texas and New Mexico, certain members at least of the formation have a more essentially marine or deep-sea type, consisting in larger proportion of pure limestones. And this composition would seem to belong to them also farther north, where they spread through the high plains east of the Rocky Mountains, and lap round the southern spurs of that great chain. Still farther to the north, or along the Missouri and its upper tributaries, where the formation is exposed through a length of more than a thousand miles, the series consists in like manner of limestones, clays, and sands, but it would appear that the latter are relatively more prevalent than farther south. An interesting constituent of the formation is the sulphate of lime or gypsum, which belongs to it more or less throughout its whole wide distribution. It is insignificant in amount in New Jersey and the Atlantic Southern States, but is more abundant in the States north of the Gulf of Mexico. In Texas and in New Mexico this valuable material exists consolidated in beds of great thickness and prodigiously wide distribution, one stratum ranging continuously from the southern tributaries of the Arkansas south-westward to the Rio Pecos, and probably to the Rio Grande, and beyond it. Wide beds of gypsum are likewise known west of the southern spurs of the Rocky Mountains.

Geographical Distribution.—The cretaceous formation would appear to constitute, throughout the middle latitudes of North America, a far wider area than any other group of strata, for it extends continuously from the very shore of the Atlantic in New Jersey, in lat. 41° N., south-westward to Mexico, westward beyond the Rocky Mountains, and north-westward to the sources of the Missouri, covering as much as 40° of longitude, and in the central tracts of the continent more than 30° of latitude. In this amazing geographical distribution, it rivals the great cretaceous deposit of Europe and Northern Africa, compared with which it forms a much more continuous area. Along the sea-board of the Southern Atlantic States it is partially concealed by a superficial covering of the tertiary strata; but from Georgia to New Mexico and the Upper Missouri it spreads in one unbroken tract, suggesting its deposition in a great continental or mediterranean sea. Commencing at the coast in New Jersey, the cretaceous series ranges thence in a contracting belt nearly to the Chesapeake Bay, where, encroached upon by the tertiary, it disappears. But we have indications of its passing under the tertiary plain of Maryland and Virginia, from the frequent occurrence of its characteristic constituent, the greensand, in both the Eocene and Miocene strata of those States. Farther south, the cretaceous formation emerges to the day in a succession of narrow exposures along the sea-board of North and South Carolina, where denuding action sweeping away the tertiary has laid it naked in the valleys of all the principal rivers from the Neuse to the great Pedee inclusive. Disappearing again below the tertiary, it emerges a second time in Georgia, on the Savannah and Ogeechee rivers. The great continuous southern belt commences in Georgia near the Oconee River, south of Milledgeville, and quickly expanding to a width of 60 or 80 miles, extends westward from the Flint River of that State through Alabama, where it sweeps round the southern promontory of the Appalachian chain and the palæozoic formations, and stretches northward, holding about the same breadth, through Mississippi and Western Tenessee as far as the western corner of Kentucky. There it crosses the Mississippi, and bending abruptly southward it ranges in a south-west course, gradually expanding in breadth into the State of Arkansas, where, deflected by the Washita hills, it once more changes its direction and sweeps westward on the southern side of that axis of older rocks until it enters the broad plains of Texas, where this fringing zone now merges into the broad expanse of the central cretaceous basin of the continent, the wide general limits of which have been already indicated. Some uncertainty yet prevails respecting the northern limit of the cretaceous rocks in the central plains north of the Missouri; nor can we trace at present with any precision the western boundary of the formation where it finally outcrops against the older rocks of Mexico, or is lost to view under the newer tertiaries and volcanic accumulations of the desert plains of Utah and Oregon. The limits assigned on the map show, however, the existing state of information derivable from a careful study of authentic documents and specimens.

Organic Remains and Equivalents.—The fossils of the North American cretaceous basin pertain exclusively to species and genera which represent those of the cretaceous strata of Europe, more especially those which characterise the upper or chalk division of that series. Though the number of species common to the

American and European basins is small compared with the whole number discovered, not exceeding probably about 10 per cent, yet 25 or 30 per cent of the known shells of the American group, now amounting to about one hundred species, are representatives of European upper cretaceous forms; and this may be considered as exhibiting as close an identity in the fauna of that period as prevails between those of the different oceans of the present day.

No mammalian remains have ever hitherto come to light, unless a species referred to the family of Seals, and called *Sternorinchus*, found in the lower greensands of New Jersey, be really a specimen of that high class; but one or two relics of wading birds have been discovered in the greensand marl-pits of New Jersey. The remains of fossil reptilia are much more abundant. One of these belongs to the remarkable saurian genus *Mosasaurus*, two or three species to *Teleosaurus*, as many to crocodile, and one or two other saurian genera. More than one species of tortoise or Chelonian reptiles have been found. Fossil fishes are also met with, especially of the genera *Carcharodon*, *Lamna*, and *Galeus*. Of upwards of sixty molluscous forms from New Jersey, not more than five or six are actually identical with European species; among these are the *gryphea costata*, *pecten quinque costatus*, and *belemnites mucronatus*; but all of them have a great vertical range through the cretaceous rocks of both Europe and America, and are therefore not expressive of very exact equivalency. The thin yellow limestone of New Jersey has furnished several corals, sponges, and other forms which seem to relate it very closely to the upper chalk of Europe, or the beds of Faxoe limestone. More than ten European species have been discovered in the cretaceous strata of Texas out of less than one hundred forms. It is worthy of note that the organic remains from the west side of the Rocky Mountains agree specifically with those of the cretaceous of the Atlantic States, as suites of specimens from the Rio Quako, and other localities of the Rio del Norte, satisfactorily show.

Lignites and fossil plants, though generally in an obscure and fragmentary condition, are frequently found in the more littoral or lower strata of the cretaceous formation in New Jersey, and the States farther south; and on the Missouri, and especially on the Yellowstone, one of its great Rocky Mountain tributaries, large deposits of lignite have been met with, having the aspect and extended stratification of beds of coal. But it is not yet perfectly certain that these do not pertain to a lacustrine eocene formation, which is known to occur in patches upon the cretaceous strata east of the Rocky Mountains. As far as the lignites of New Jersey have been examined, they exhibit a vegetation closely agreeing with that of the cretaceous period of Europe.

Physical Geography of the Cretaceous Era.—An examination of the wide cretaceous deposits of the United States indicates a striking difference between the physical geography of this period and that now prevailing. It shows us, as a glance at the Map will prove, that, whatever may have been the area of dry land occupied by the ancient palæozoic formations in the long interval which elapsed between the first elevation of those strata and the establishment of the boundaries of the cretaceous seas, the boundary or true shore of North America at the beginning of the cretaceous deposits was that long undulating line which marks the inner or continental margin of the Atlantic and Gulf of Mexico plain, stretching from New Jersey along the foot of the true Atlantic slope to the end of the Appalachians, thence northward to the mouth of the Ohio, then south-westward to the Red River, and northward from that to the Upper Missouri. Inside or north of this winding shore lay the smaller North American continent while the cretaceous rocks were forming; and eastward, southward, and westward of it spread the Atlantic Ocean, unbroken by masses of land as far as to where the Rocky Mountains and the chains farther to the west lifted themselves in the form of a great oceanic archipelago, and to where the great Pacific chain bounded that sea, and either entirely or partially confined it from the ocean to the west. The cessation westward of the cretaceous deposits seems to imply that the now central plain of the continent was in the cretaceous era occupied by a huge arm of the ocean, or great northward elongation of the present Gulf of Mexico, which washed the base of the western Cordillera, as far towards the north or farther than the upper waters of the Missouri, just as the Mexican Gulf now washes it in the tropical latitudes. The gigantic scale of the actions which accumulated the cretaceous sediments over this vast inland sea, and those which uplifted it, and drained and denuded its sediments, may be conceived from the simple facts that these deposits must possess in the interior of the continent the thickness of some thousands of feet, and that vast tracts of them now constitute the great plateaus of the country lifted from 2000 to 6000 feet above the level of the sea.

CAINOZOIC, or Tertiary Formations.

Applying the term Tertiary or Cainozoic to all those deposits which intervene between the cretaceous series and the accumulations which are now in progress, deposits entombing the relics of races more or less analogous to the forms which now people the globe, but not identical with them, I shall proceed to describe the several subdivisions of the series in conformity with the classification which the phenomena require. The American Tertiary strata are separated by nature into four distinct groups, equivalent, approximately, to the Eocene, Miocene, Pliocene, and Pleistocene groups of Europe. These tertiary divisions of the two continents are co-ordinated with each other, through a sufficient number of identical organic remains, and through such a general analogy in their types or correspondence in the *facies* of the fossils, as to justify the appropriation in the absence of a more philosophical nomenclature based on distinctions of time, of the same names to the corresponding divisions of the two series.

The Tertiary deposits of the United States—omitting for the present the latest member of them, or the Boulder-drift and the Pleistocene sediments associated with it, occupy, as will be seen by a glance at the Map, chiefly the two oceanic slopes or borders of the continent.

Atlantic Belt.—The Atlantic, or eastern belt, commences at the north in the islands of the southern coast of New England and New York. Entering the main land in the east coast of New Jersey, it stretches thence, in a long belt, of an average width of about a hundred miles, constituting the Atlantic tide-water plain, through all the seaboard States to Florida, the whole surface of which it seems to cover. From Florida, it ranges westward to the Mississippi, the valley of which it ascends for several hundred miles, beyond which it ranges, again contracting in breadth, through Louisiana and southern Texas, until it crosses the Rio del Norte, and trending southward, skirts the western coast of the Gulf of Mexico. It is a very well defined undulating zone, fringing the present continent in the form of a very level low plain, that scarcely anywhere rises to one hundred feet above the level of the sea. This plain has a sandy surface, contains the tidal estuaries of all the Atlantic rivers between the Hudson and those of Mexico, and is intersected with innumerable sluggish creeks, and on its oceanic margin with a net-work of low swamps and tidal meadows, particularly through the Southern and Gulf States. Within the territory of the United States alone, the length of this belt, including Florida, exceeds 2400 miles; and if we add the portion in Mexico, it makes its length from Cape Cod to Vera Cruz not less than 3000 miles. All the four divisions of the tertiary, excepting the drift and its accompaniments, are included in this long zone of marine deposits.

In the Geological Map, one uniform colour—a very pale brown—represents the tertiary strata generally, where the special formation has not been well ascertained; and modifications of this colour are employed for the special formations, where the existence and limits of these are sufficiently known,—a darker brown for the Eocene; a bluish tinge for the Miocene; a yellowish, with bars, for the Pliocene; and a faint smooth yellow for the Pleistocene. Through a slight error in the Key or Table of Colours, the term *Quaternary* is affixed to this last yellow tint, instead of the name *Pleistocene*; quaternary being properly reserved for the formations which are now in progress, or which have occurred since the last disturbances of the levels of the continent, which exterminated its Pleistocene quadrupeds, and strewed the drift over its northern latitudes.

Pacific Slope.—The Pacific slope of the continent, from the Rocky Mountains to the sea, is extensively covered with tertiary deposits of both marine and volcanic origin, the whole being divided into two great zones by the Pacific range of mountains, or the Sierra Nevada and Cascade chains. The broadest and most irregular of these western tertiary areas covers apparently the entire breadth of the western desert table-land, including the Utah salt desert, and the volcanic desert of Oregon and Washington; occupying, in other words, nearly the whole space between the Wahsatch and Rocky Mountains on the east, and the Sierra Nevada and Cascade chains on the west, and stretching longitudinally northward a little west, from the Cordilleras of Mexico into British and Russian America. In its southern prolongation, this great tertiary tract declines from its average high level of more than 4000 feet to the sea-level, and even below it, at the Gulf of California; for, north of that arm of the sea, a portion of the Colorado desert is depressed below the oceanic plain, in one place, to the amount of nearly 300 feet.

The other, or western Pacific belt of Tertiary, fringes the continent in a long and narrow strip, confined between the western base of the great Pacific mountain chain and the actual coast. This narrow zone is traceable from the southern end of the peninsula of California, north-westward or northward, along the whole border of the continent, as far as Russian America, over a distance quite as great as the eastern or Atlantic zone. These western tertiary areas include the same four great divisions of the Cainozoic strata found on the Atlantic side of the continent; and, what is very interesting, they exhibit, in the organic remains, not only the general types or distinctive facies, significant of the period of their formation, but in each case the ordinary proportion of identical species. This occurrence of the same succession of tertiary formations on the two great ocean fronts of the continent, is indicative of the amazingly wide areas over which even the later crust movements of the globe have extended. For there can be little doubt that the disturbance which changed the Eocene and other waters on the Atlantic side, were contemporaneous with those which altered their sediments and their living races, on the opposite oceanic slope.

Central Tertiary Tracts.—Besides the two grand continuous oceanic areas of tertiary strata, the continent contains, in its more central districts, a number of detached tertiary deposits, of probably more than one epoch. A glance at the Map will indicate the position of several of the more important of these along the western side of the high plains east of the Rocky Mountains. These, which for the most part are Eocene fresh-water basins, seem to belong to a great central or continental zone of tertiary deposits, which extends from a little north of the Missouri, or from the east and west water-shed of the continent, northward, in a long and narrow tract, parallel with the Rocky Mountains, to the valley of the Mackenzie River, and by it to the shores of the Arctic Sea. Other more or less insulated deposits of the tertiary strata occur on the opposite or western side of the Rocky Mountains, between them and the Wahsatch chains; the best known of these are shown upon the Map. That on the upper waters of the Green River, between the south pass and Fort Bridger, would appear, like all the best known of the interior basins, to be of Eocene age. Very probably there are numerous and even extensive patches of tertiary strata capping the wide cretaceous deposits in Kansas, New Mexico, and Texas, of which we have at present no specific information; but these could not be indicated upon the Map, in the present vague condition of the information attainable regarding the geology of that little-explored semi-desert region.

Eocene Formations, Atlantic Slope.—No strata of Eocene age have been discovered in North America, to the eastward of the meridian of the Chesapeake Bay, either in the Atlantic coast or in the interior. But from the Potomac River, southward and westward, they occur in numerous localities, so scattered as to give the impression that the whole of the Atlantic tide-water tertiary plain, as far at least as Texas, is continuously underlaid by the formation. Throughout this zone, wherever Eocene beds appear, they present an extremely gentle inclination towards the Atlantic and Gulf of Mexico, not greater than belongs to the shelving bottom of those waters at the present time, for an equal distance from the coast. Their very slight seaward dip is not the result, therefore, of any uptilting action in the earth's crust, but a consequence of an original trivial obliquity of their plains of stratification; the whole Atlantic front of the continent, and probably the entire continent itself, having been lifted out of the sea at the successive tertiary epochs, either horizontally, or with extremely low crust undulations.

Tracing the individual outcrops of the Eocene upon this plain, the first which we encounter, going southwards, is a long narrow belt, extending from the Potomac, near Washington, across Virginia and North Carolina, to a point beyond the Cape Fear River. Throughout this line these strata run, in almost horizontal position, against the older upturned gneissic rocks of the Atlantic slope, and in some places in Virginia against the nearly horizontal beds of the Jurassic coal formation. They are overlaid by a parallel thin deposit of the Miocene tertiary strata, which, on the more upland tracts between the river-valleys themselves, also abut against the older formations, hiding the Eocene from view. The latter is therefore chiefly exposed in the ravines and river sections. All along the line of outcrop, the proper Atlantic slope meets the level Atlantic tertiary plain by an abrupt change in the surface, suggesting an ancient shore; and the line of junction is everywhere marked by a sudden change in the rivers, from the condition of running streams to that of tidal estuaries, each river usually having rapids of considerable extent before it falls into the tertiary plain.

This important physical feature, which prevails, indeed, from the Delaware, at Trenton, to North Carolina, has determined in a striking manner the sites of the principal cities of the whole sea-board of the Middle and Southern States. The upper limit of the tide in the Atlantic rivers being the natural limit of free navigation, it became the natural place for the transhipment of commodities. This circumstance, and the presence of the water-power of the streams, determined the selection of this boundary for the chief commercial towns in the first settlement of the country; and thus it is that Trenton, Havre de Grace, Philadelphia, Baltimore, Washington, Fredericksburg, Richmond, Petersburgh, Halifax, Raleigh, Colombia, Augusta, Maçon, Columbus, and Montgomery in Alabama, are all seated upon this great natural ancient shore.

Another belt of the Eocene deposits stretches from the Cape Fear River nearly to the Altamaha in Georgia, holding a more central position in the Atlantic plain, between the sea and the upper country, than the previously described outcrop, and being more interrupted by the overlapping of the newer strata on the water-sheds between the rivers. From the place occupied by this line of exposures, we are entitled to infer something like a very slight arching of the surface at the time of the uplifting and denuding of this part of the Atlantic plain.

Another still larger patch of the Eocene formation extends from near Milledgeville on the Oconee River in Georgia, westward in a narrow belt, across that State, and across Alabama, to the Alabama River, where it commences to expand rapidly, its southern border separating it from the Upper Tertiary formations, ranging nearly westward to the Mississippi at Grand-Gulf, and its northern turning northward, and running through the States of Mississippi and Tennessee, till it meets the Mississippi only a short distance below New Madrid. In the immediate valley of the Mississippi, the western margin of this broad Eocene tract is formed by the overlapping of the newer alluvium of that mighty river. In Louisiana and Texas there are only two at present distinctly known patches of the Eocene strata—one on the Nueces River, west of Nagadoches, the other on the Rio Brazos, south of Franklin. Nearly all the other portions of the extensive Tertiary plain of these States expose only the Pliocene and Pleistocene, and the wide modern alluviums of the existing rivers, though there can be little doubt but that the Eocene underlies the whole.

Eocene Strata of the Central and Western Parts of the Continent.—In several places east of the Rocky Mountains, broad patches of Eocene deposits cover the cretaceous strata in the high half-sterile steppes of the great interior plains. How far south these shallow tertiary basins there extend we are at present unable to say, but there are probably some of them in Kansas, and even in Northern Texas, as we know there are to the west of the Rocky Mountains, in New Mexico and Utah; but going northward we encounter a larger basin on the upper waters of Nebraska or Platt River, extending from the forks of the Platt nearly to Fort Laramie, or almost 200 miles. Another insulated basin exists in the same meridian somewhat farther north, at the sources of the White Earth and Sheyenne rivers of the Missouri, and extending nearly to the foot of the Black Hills. This tract contains the celebrated *Mauvais Terres*, or Bad Lands, a desert region of arid table-lands gashed into innumerable ravines, vertical precipices, and detached, flat-topped, turreted columns, by deep denudation—an extraordinary labyrinth of 30 or 40 miles' diameter. In both of these basins, certainly in the more northern one of the Bad Lands, the deposits are exclusively of fresh-water origin, as will be shown presently in speaking of their organic remains. What the precise age may be of the tertiary deposits upon the Upper Missouri, and still farther northward on the Saskatchewan and Mackenzie rivers, it is impossible at present to say, no sufficiently distinctive organic remains having yet been reported; but it is highly probable, from their position in the prolongation of the known Eocene belt, that some of these are of that age. In the region between the Rocky Mountains proper, or Chippewayan chain, and the Wahsatch Mountains of Utah, there occur several detached patches of what seem to be, from the evidence of their fossils, true Eocene strata. These, like some of the basins east of the Rocky Mountains, contain numerous beds of lignite or tertiary brown coal, often mistaken by travellers for genuine coal of the carboniferous formation. The lignites and leaves of deciduous and coniferous trees, and some few molluscous fossils, all go to prove that some of these strata at least were accumulated in fresh-water lakes. Indeed, on both sides of the Rocky Mountains we have proofs of physical conditions in the early tertiary times not unlike those which prevailed in the Eocene ages in France and other tertiary countries of Europe, where lakes and estuaries entombed the remains of terrestrial and fresh-water animals and plants; and volcanic disturbances shortly afterwards arose to uplift and alter or entirely drain them.

We know too little as yet of the tertiary rocks of the high central table-lands between the Rocky Mountains and the Sierra Nevada to pronounce upon the age of the widespread tertiary strata which cover them, but certain considerations connected with the physical geography suggest that these desert plains must contain many fresh-water sediments, and make it probable that among them are some of Eocene age. To the westward of the great Californian chain, by far the larger portion of the tertiary strata occupying the Pacific slope appears to be of Miocene date; but some genuine Eocene rocks are known to exist there, though covering comparatively very limited tracts. The principal localities of these are in Southern California, north of the Los Angeles Mountains, or on the verge of the Colorado Desert.

Description of Eocene Strata.—A considerable diversity of composition prevails in the North American Eocene strata. Those of the Atlantic sea-board, exclusively marine in their origin, are very arenaceous in their more northern development, but become more calcareous as we trace them southward and westward through the Southern States. In the Virginian outcrop the materials are chiefly argillaceous micaceous sands and sandy blue clays, sometimes slightly calcareous and a little gypseous, and frequently possessing a minute quantity of the green granules so characteristic of the cretaceous formation scattered through. Throughout this belt there is very little limestone

The middle Atlantic belt, or that exposed upon the rivers of North Carolina, South Carolina, and Georgia, is a much more calcareous formation, consisting of ferruginous and silicious sands, lead-coloured sandy clays, and whitish and bluish friable limestones, with one or more beds of porous chert or burrstone, employed in some localities for millstones. All of these beds are more or less fossiliferous, and some of them excessively so.

The third and next great belt, or that which extends from the Ocmulgee River in Georgia to the Mississippi, may be described as a great triple formation. The upper member consists of two limestone strata, the higher composed largely of that singular foraminiferous fossil, the nummulite, or *Orbitoides*, whence it has been called the nummulitic limestone; and the lower, of a white porous limestone called commonly the rotten limestone remarkable for containing the bones of a gigantic but slender whale-like creature, the *Zeuglodon cetoides*.

This division considerably exceeds 100 feet in thickness in some localities. The middle member is a ferruginous silicious sand and sandy marl, with a thickness of usually more than 100 feet. It abounds in the well-known Eocene shell, the *Cardita planicosta*, and contains the curious *Ostrea sellieformis*, a fossil which equally characterises the Eocene beds of Georgia and Virginia. The lowest member is a complex limestone and marly deposit of undetermined thickness, but exceeding considerably 100 feet. In this bed occur the above-named and many other shells of characteristic Eocene types. Such is the general aspect of the strata in Alabama and Mississippi.

In Texas the Eocene deposits are likewise both arenaceous and calcareous, the sands being some of them very ferruginous and red. Some of the limestone beds abound in fossils.

In the territory of Nebraska the fresh-water Eocene basin of the Bad Lands consists chiefly of silicious indurated clays, marls, and very compact white argillaceous limestones, some of the clays and limestones abounding in admirably-preserved remains of fossil turtles and extinct pachydermatous animals.

Of the Eocene deposits west of the Rocky Mountains we possess too little information at present to describe with accuracy their composition, further than that some of them contain shales and marls, abounding in lignites and in lacustrine shells and other fresh-water remains.

Fossils and Geological Equivalents.—Throughout the Atlantic sea-board plain—intending this expression to include the tertiary plain fringing the Gulf of Mexico—the Eocene strata possess certain characteristic fossils, particularly many species of shells which are common to all the districts. Some of these, and a few corals and fishes, are identical with European Eocene forms, while many others are only generically representative of European forms. There can be little doubt, therefore, that the Eocene strata of the two continents are co-ordinate in age. Nevertheless, it is not a little remarkable that the two formations are connected by a very small proportion of strictly identical or common organisms. Thus, while more than four hundred species of marine shells, and many echinoderms and remains of fishes have been procured from the very fossiliferous locality of Clayborne, Alabama, not more than eight or ten of these, or only two or three per cent, prove, upon comparison, to belong to known European types. Notwithstanding, this whole extensive group of organic remains has an unequivocally Eocene facies. Of the remains of fishes the most abundant are the teeth of several genera of sharks—*Carcharodon*, *Otodis*, *Lamna*, and others—belonging to races still higher in the scale. The Atlantic Eocene beds of North America contain several very interesting reptilian forms, among them some species of crocodiles, gavials, and turtles. No terrestrial mammalia, or land quadrupeds, have hitherto been discovered, nor from the marine origin of the beds are such likely to be readily found; but cetacean or oceanic mammalia, as already intimated, do frequently occur, as the zeuglodon of the rotten limestone of Alabama shows. This creature was a kind of slender whale, with yoke-shaped teeth not unlike those of the seal; its vertebræ, as thick as those of the largest whale, were twice as long, and the entire animal had a length, as shown by some specimens, of 70 or 80 feet.

Fossils of the Nebraska Eocene Basin.—Many bones of extinct quadrupeds and land or fresh-water turtles have been discovered in a state of beautiful preservation in the Bad Lands of Nebraska. Among these are the remains of two species of rhinoceros, two species of Archæotherium, a pachyderm resembling the Cheiropotamus of the Eocene basins of France, and a gigantic palæotherium, larger than that of Paris; likewise a species of *Pœbrotherium*, an extinct ruminant, and another ruminant, the *Agriochœrus*. Besides these are several species of the new genus *Oreodon*, which united the characters of pachiderms and ruminants,—a kind of huge ruminating hogs. With these was a large carnivorous animal of the ferocious genus *Machairodus*. Many of these remains are significant of the period of the Upper Eocene deposits of France. The turtles belong chiefly to the genus Testudo.

Physical Geography of the Eocene Era.—It is obvious from the relations of the Eocene and other later tertiaries to the cretaceous strata upon which they repose, that however extensively these latter were laid dry at the epoch of the drainage of the great basin in which they were formed, those parts of that basin now overlaid by the tertiaries must have remained under water, or, if lifted, must have been immediately depressed again to the limit of that great tertiary shore-line already traced as the inner boundary of the Atlantic plain. Throughout this plain the Eocene strata was quietly deposited in what was evidently a very shallow sea, their materials being derived from the sediments of the rivers descending the Atlantic slope, and the great gulf slope or southern part of the interior continental table-land. It is worthy of note that opposite the Atlantic slope and Appalachian Mountains, where so large a proportion of the rocks are of a composition to furnish only sandy and clayey sediments, the Eocene deposits of the Atlantic plain are chiefly arenaceous and argillaceous in their composition; and that farther west, where there is a wide expanse of limestones occupying the great hydrographic basin of the Mississippi and the plains and mountains to the west of it, the Eocene deposits fringing the Gulf of Mexico are greatly more calcareous and less arenaceous in character. We know at present too little of the geology of the borders of the scattered Eocene basins of the interior of the continent to speculate with profit respecting the physical geography of those regions in that morning of the great Tertiary day, but we may safely conjecture that the draining dry of the great inland Eocene lakes must have been accompanied by no inconsiderable elevation of the regions bordering the Rocky Mountains, probably by a general bulging of the whole central water-shed of the continent. So long as the zone of country east of the Rocky Mountains which includes these basins was occupied by the great lakes, the present Missouri River, draining as it does one uniform broad slope towards the east, could have no existence; but there is nothing in the geology of the interior of the continent which forbids the supposition that its present outlines may have been established at the epoch of the movement which terminated the Eocene and began the Miocene formations.

MIOCENE STRATA of the United States.

Geographical Distribution.—The Miocene deposits of the United States, as at present known, are confined almost exclusively to the two oceanic tertiary belts—that which borders the Atlantic and Gulf of Mexico, and that which skirts the Pacific. Possibly there are strata of this epoch in the desert table-lands between the Rocky Mountains and the great Pacific chain, and there may be some isolated basins in the broad steppes of Kansas, Western Texas, and New Mexico, but of such we have at present no satisfactory evidence. The best-determined Miocene tracts are indicated upon the Map in a blue shade laid upon the pale brown appropriated to the tertiaries; those upon the Atlantic plain being very faintly tinged, those upon the Pacific border much more darkly. In describing these, we must remark that very probably there exist other patches of the formation besides those represented, but that it has been deemed expedient, for the sake of greater accuracy, to sweep the general tint assigned to the tertiary strata over all districts where the special formations have not been accurately ascertained. In the progress of research, it will very probably appear that wide tracts of the Atlantic plain in the Southern States, including Texas, are underlaid by Miocene strata exposed at intervals in the river-valleys; and the same remark may just be applied to the Eocene. In like manner, it is very probable that Miocene strata occur at intervals along both coasts of the peninsula of Lower California.

Miocene on the Atlantic.—Restricting our attention, in the first place, to the well-ascertained Miocene areas of the Atlantic border, we find that they are all embraced in that part of the tide-water plain which extends from Martha's Vineyard, on the coast of New England, to the neighbourhood of the Cape Fear River in North Carolina, and in other detached patches farther south, as far as Georgia. Martha's Vineyard consists almost entirely of this formation, and Long Island appears to be, in part at least, underlaid by it. The principal area, however, is on the mainland, where it appears first in two or three very shallow patches on the eastern and southern coasts of New Jersey, and then in a wide continuous sheet, covering nearly the whole breadth of the Atlantic plain from the Delaware Bay to the Neuse River, abutting on its western margin against the older metamorphic rocks, at the base of the inner Atlantic slope, and fringed on its eastern by a thin capping of Pliocene deposits, stretching from the Chesapeake Bay to Pamlico Sound. Over all this tract the Miocene beds are abundantly exposed in the banks of the rivers and creeks, where they are now becoming extensively sought for, their calcareous shell marls being applicable to the purposes of agriculture.

Description.—The Atlantic Miocene deposits consist, for the most part, of yellow and brown ferruginous sands, sanded blue clays, and calcareous clays and sands, imbedding extensive layers of uncemented fossil shells, and other extinct organisms. As a mass, the formation contains fewer cemented beds than the Eocene of the more southern States, not having any true limestones or silicious burrstones. It resembles, in general composition, more closely the underlying Eocene of its own district, even in possessing a certain proportion of the green sand characteristic of the cretaceous group which underlies them both.

Pacific Belt.—Though we are much less accurately acquainted at present with the distribution of the Miocene strata on the Pacific slope of the continent, we are enabled, by assembling the observations of different explorers, to represent at least one great belt as covering a large portion of the long narrow sea-board belt which intervenes between the western base of the Sierra Nevada and Cascade Mountain and the coast. It is believed that the chief part of the tertiaries of this diversified zone belong to the Miocene period, but it is very probable that future researches will disclose not only Eocene, but Pliocene and Pleistocene deposits there. As already intimated, this margin of the continent differs essentially from the Atlantic tertiary plain in its physical features, which are those of a broken and hilly tract, sloping rather steeply towards the sea, traversed transversely by rushing rivers, undulated by chains of ridges and even mountains, and in other quarters dotted with volcanic hills. As might be expected from such a topography, the tertiary beds are seldom in a horizontal position, but are uptilted and dislocated, and disposed in great undulations, the axes of the waves conforming in their directions to the general trend of the coast and the older mountains. The Coast Mountains, so called, and the Monte Diavolo range, consist largely of the Miocene strata, thus undulating. These seem to repose, in many places, immediately upon the crystalline stratified rocks; in other localities they rest directly upon ancient tertiary trachytes, and other effusions of extinct volcanoes.

Description of the Strata.—As we might anticipate, from the more disturbed and volcanic character of the immediate Pacific slope, as compared with the Atlantic plain, the tertiary strata of California and Oregon are in a greatly more indurated or rocky condition than those of the eastern coast. They consist largely of sandstones, conglomerates, and shales, with occasional beds of chert, but very rarely any of limestone. Some of the sandstones are fossiliferous, the organic remains which they contain being sufficiently well preserved to establish their Miocene age. Extensive beds of infusorial earth belong to one portion of these upper tertiary strata, and occur at intervals for more than 400 miles along the coast belt. A very interesting bed of infusorial earth, consisting chiefly of various forms of fossil Diatomaceæ and Desmidiæ, occurs near the base of the Miocene formation, above its contact with the Eocene, in the State of Virginia. This has been traced, at intervals, from the Potomac to the Meherrin rivers, on the southern borders of Virginia, a distance of more than 150 miles. In some places its thickness is from 20 to 30 feet, and it is made up almost exclusively of the silicious cases of these microscopic organisms.

Fossils and Equivalents of the Miocene.—The Miocene tertiaries of the Atlantic plain consist of about two hundred well-ascertained species, comprising corals, molluscs, certain crustaceans, several fishes, chiefly of the shark tribe, a few reptiles, and one or two cetaceans or marine mammalia. Of the shells and corals not more than 20 per cent can be recognised as belonging to races now alive; nor is it probable that future researches will materially modify this proportion. Very few of the extinct species are common to the strata of America and Europe, and out of one hundred and forty-seven of the American fossil forms, including both extinct and recent, reviewed by Sir Charles Lyell, only thirteen were found to be likewise European. Several of the most abundant of these Miocene remains are recent species now restricted to the western or American side of the Atlantic. The Miocene shark's teeth appear, some of them, identical with those of the middle tertiary strata of Touraine. The nearest European equivalents of the Atlantic Miocene beds would seem to be the English crag and the faluns of Touraine.

Notwithstanding the large number of species of molluscous and other remains found in both the Eocene and Miocene Atlantic tertiaries, it is worthy of note that very few of these, indeed not more than two or three per cent, are possessed in common by the two formations, showing a very remarkable extermination of the inhabitants of the ancient tertiary coast. This fact respecting the almost total revolution in the inhabitants of the tertiary waters, at the change from the Eocene to the Miocene deposits, is itself significant of a widespread alteration in the physical conditions of the region. This was no doubt a change in the level of the bed of the sea, amounting, probably, to its temporary desiccation, reimmersion, and almost certainly to a modification of its currents, its temperature, and the nature of its sediments, though the Eocene beds were neither permanently uplifted nor indurated, but left in their original horizontality beneath the ocean level, as a floor for the reception of the parallel Miocene strata. There can be little doubt that the changes here mentioned all came about, filling the waters for the abode of new species, and even many new genera. How much actual time may have elapsed between the cessation of the Eocene and the beginning of the Miocene sediments, for the extirpation of the one group of living races and the creation and diffusion of the succeeding, we have no data for estimating, but that some interval elapsed is sufficiently obvious.

On the Pacific side of the continent the phenomena are somewhat different, the levels appearing to have been more disturbed than on the Atlantic border at the close of the Eocene period. But we know at present too little critically of the tertiary geology of California and Oregon to interpret safely what the revolutions exactly were at the several tertiary epochs. The effusion of volcanic materials early in the tertiary ages must have complicated greatly the tertiary physical geography of that side of the continent.

Pliocene and Pleistocene Strata.—Applying the terms Pliocene and Pleistocene to those tertiary deposits which were produced in the periods between the times of the Miocene formations and the recent existing order of things, this designation will include several late tertiary tracts, both on the Atlantic plain and on the Pacific slope. Very probably these deposits are not all of one age, but it is impossible in the present stage of research to place them under an exact chronology. It seems most probable that many of the so-called Post-pliocene fossiliferous beds of the Atlantic sea-board are contemporaneous with the superficial strata farther north which belong to the Pleistocene series. It will suffice for our present purpose to describe them as we know them.

Pliocene and Pleistocene Beds of Virginia and North Carolina.—The formation of Pleistocene age with which we are best acquainted is a thin deposit of shelly sands skirting the coasts of the Chesapeake Bay from the St Mary's River southward, and covering a broader belt of country on the Atlantic coast of Virginia and North

Carolina as far as Pamlico Sound. These beds are characterised by shells, nearly all the species of which are identical with forms now occurring somewhere on the Atlantic coast, one or two of the most common species living now only in the warmer waters of the Gulf of Mexico. Mixed with these shells are the bones and teeth of several genera of extinct land quadrupeds: the fossil elephant or mammoth, the mastodon giganteum, and a species of horse somewhat larger than that now living. Still farther south along the sea-board occur other modern tertiary deposits differing from these somewhat in composition, but apparently equivalent to them in age. They are characterised by the presence of fossil shells, and other marine and estuary remains, belonging to species now inhabiting the adjacent coast, associated with the relics of many interesting extinct quadrupeds.

Another Pleistocene deposit skirts the shores of Mobile Bay and the adjacent coast of the Gulf of Mexico. This contains some beds abounding in fossil shells identical with species now living in the Gulf. It is very probable, indeed almost certain, that there exist similar uplifted recent tertiary beds in many other places, both along the Atlantic coast and that of the Gulf of Mexico, but they have been too imperfectly examined to admit of being here described. Very possibly, too, strata of pliocene age, of lacustrine or fresh-water origin, exist in the interior of the continent. Recent researches render it probable that some of the more superficial tertiary strata of the west coast of the continent, especially in California, appertain to this period; indeed, at several localities on the coast of that State, raised beds occur, abounding in marine shells nearly identical in species with those now existing in the Pacific, but associated with mammalian remains, that imply an elevation at either the Pliocene or Pleistocene periods.

CALIFORNIAN PLEISTOCENE BEDS.—California contains several interesting pleistocene deposits, and it is probable that there are others farther north on the Pacific slope in Oregon. The recent researches of Mr Blake and Dr Trask have shown that several of the lower tracts on the west side of the Sierra Nevada are of this age. The longest pleistocene belt fills nearly the entire length of the valley of Middle California, or that of the Sacramento and San Joachim rivers, including the basins of the Tulare lakes. This plain or trough of pleistocene is the main auriferous region or gold basin of California; but the tertiary alluvium is not confined to the bed of the valley, it penetrates the lateral ravines at the base, and even ascends the longer ravines high upon the flanks of the Sierra Nevada. To the west of this main belt occur two or three other parallel strips of upraised post-pliocene. One of these fills a part of the Napa valley, another lesser one occurs in the Santa Clara valley, and a third runs from the Bay of Monterey up the valley of the San Antonio. Perhaps the most interesting of all the post-pliocene tracts belonging to the Pacific slope is that which extends northward from the head of the Gulf of California into the Colorado desert. This is a low plain or valley, having a well-defined sea-margin or ancient coast-line for its boundary, and consists of a fine silt or clay, the deposit evidently of the waters brought into the Gulf of California by the Colorado River. The remarkable feature connected with this valley deposit is, that a large portion of its surface is at and below the existing level of the ocean—a region, in other words, of continental depression. Barometric measurements at some parts of the ancient gulf-margin referred to now stand 80 or 90 feet beneath the mean level of the sea; while Mr Blake and other observers testify that at their barometric stations the plain visibly sinks from both sides towards the centre at an inclination quite visible to the eye; so that they infer that the middle parts may be even between 200 and 300 feet lower than the surface of the sea. A very slight swell of the plain a little north of the mouth of the Colorado seems to have insulated this depressed area from the waters of the gulf; indeed, it is very probable that the same movement of the earth's crust, doubtless some earthquake convulsion which lifted the plain in this neighbourhood, depressed the district farther north. The whole phenomenon is thus easily explained on the supposition that the Gulf of California extended in the pleistocene period to the head of this low plain, and that an earthquake movement of the whole region lifted slightly the continent from its previous level with a low swell or undulation transverse to the ancient gulf near the mouth of the Rio Colorado. The excessively dry character of the prevailing winds of this region will account for the absence of a lake in this depressed part of the Colorado Desert. The presence of much sea-salt in the soil, amounting in some localities to a white efflorescence upon the surface, like a permanent hoar-frost, shows not only how the ancient gulf-waters may have been evaporated by the parched atmosphere, but how those of any lake which may at first have existed there fed by the back-water of the Colorado in its times of freshets, may also have been drunk up. The Tulare lakes of the Joachim Valley offer at this time a condition of things somewhat parallel to that which is here assumed, for throughout the long dry season of California these are little else than broad level meadows, from whence the waters have been exhaled by the drying action of the climate, and only in the wet season are their wide marginal tracts covered with a thin sheet of transient rain-water.

FOSSILS OF THE ATLANTIC PLEISTOCENE STRATA.—The pleistocene beds on the Potomac River in St Mary's county, Maryland, contain, associated with several species now living in the Chesapeake Bay, an estuary shell, the *Gnathodon cuneatus*, now restricted to the warmer waters of the Gulf of Mexico; and the similar recent tertiary deposits on the Neuse River, Carolina, show a mingling of the gnathodon with shells of the southern Atlantic coast. The more northern locality has produced no bones or teeth of extinct land animals, but from the Carolina formation have been procured those of the elephant, mastodon, and horse, as already mentioned. The modern tertiary beds between the Altamaha and Turtle rivers, Georgia, contain, along with shells of species now inhabiting the neighbouring waters, remains of the mastodon, elephant, horse, hippopotamus, bison, megatherium, and mylodon, these pachidermic and edentate genera pointing to an identity of period between the Georgian deposits and the superficial tertiaries of Patagonia, where Darwin and other naturalists found a similar association. Some of these species, the *Mastodon giganteum* and the *Elephas primogenius*, occur, as will be stated presently, in the upper deposits of the North American pleistocene drift, showing most probably that all of these later tertiary formations were produced and uplifted about the epoch of the superficial boulder deposit.

THE NORTHERN PLEISTOCENE, OR GREAT BOULDER DRIFT.

Throughout the greater part of the continent of North America, from about the latitude of 40° northward, the rocky floor of the country is covered to a greater or less depth with that well characterised formation called the *Northern Boulder Drift*. In many districts this is a complex group of deposits, consisting of three or more formations, denoting at least three distinct epochs, and at least three distinct conditions or changes in the physical geography. In the north-eastern part of the United States, extending to the adjacent British Provinces, this triple division of the Northern Pleistocene Series is well characterised, and admits of the following brief description:—

1. The first or lowest deposit is a prevailing, indeed almost universal, stratum of boulder drift, reposing immediately upon the rounded, scratched, and polished surface of the general rocky floor of the continent. This loose heterogeneous material is composed of gravel, sand, and clay, and boulders more or less rounded, of all sizes, the whole rather promiscuously mingled, but generally stratified, the stratification being in oblique and often abutting planes of deposition, denoting turbulent and conflicting currents. This is the general character of the drift in all upland positions, and even in the river-valleys over New England and the Northern States. In some more restricted localities, immediately contiguous to the ocean, as around the harbours of New York and Boston, the drift has more the character of the European boulder clay, consisting of a mixture of sand and clay, destitute of lamination or stratification on the small scale, and imbedding boulders of various sizes irregularly scattered through it. The boulders and pebbles in both the stratified and unstratified drift are themselves smoothed and striated, and blunted and rounded on their edges, showing signs of having undergone a great amount of attrition. The materials composing this remarkable formation belong invariably to rocks lying north or north-west of their present positions, and in many districts are traceable to remote localities, even across broad plains, deep valleys, great sheets of water, and over chains of hills, and even across lofty mountains. The boulders have evidently not radiated from any centres of dispersion; they exhibit a progressive diminution of size as we trace the same kinds southward from their parent rocks, though solitary blocks of large dimensions occur within and upon the general mass of sand and gravel. But even these boulders show the same rapid diminution in size as we follow them southward. In wide and level districts the larger boulders are frequently seen uniformly but sparsely scattered over broad tracts of country. In other quarters, where the surface is more diversified, they frequently form long narrow belts, the borders of which are sometimes remarkably parallel. The direction which the drift matter has taken conforms generally to that of the scratches upon the rocks beneath; and in the hilly districts of New England, New York, New Jersey, and Pennsylvania, it is for the most part obliquely across the crests of the mountains. Lower on the slopes, and in the beds of the longitudinal valleys, it conforms partially to the courses of the great hollows in their surface, as if at those lower levels it had been deflected by the previously established lines of easiest drainage. One essential phenomenon is the occurrence of blocks, some of them of considerable size, high on the slopes and summits of mountain ridges and table-lands, a thousand or fifteen hundred feet above the level of their parent rocks.

SOUTHERN LIMIT OF THE DRIFT.—The southern visible limit of the continuous drift stratum, in the British Provinces and in New England, is the sea-coast. From the estuary of the Hudson it trends inland, following an irregular undulating line westward, across New Jersey and Northern Pennsylvania to Ohio, and the States farther west. On the mountains and table-lands its position is invariably farther north than on the plains and in the valleys between them. And it projects long tails far to the southward of its general average boundary, through the great north and south valleys which open southward towards the Atlantic and Gulf slopes, through the Appalachians, and across the water-shed south of the great lakes,—the gravel and boulder matter even extending hundreds of miles down the valleys of the Delaware, the Susquehanna, the Alleghany, and the Mississippi rivers. It seems to have been arrested in its progress southward by the high table-land of Northern Pennsylvania, only the lowest depressions in this plateau admitting it farther southward with the slope of the continent.

STRIATED ROCKY FLOOR OF THE DRIFT.—The rocky surface upon which the drift reposes is everywhere furrowed and smoothed, except upon the steep southern or lee sides of the hills, where the outcropping strata retain an unworn or craggy aspect. The smoothed and striated region is nearly coextensive with the area covered by the drift, only the furrows grow faint, and even cease altogether, in many elevated districts, at a point some miles to the north of the ultimate margin of the attenuated bed of drift or of scattered boulders. This worn condition of the surface occurs at all altitudes, from the sea-level to the summits of the loftiest mountains in New England, New York, and Northern Pennsylvania. Only the culminating peak of Mount Washington, the highest point south of the valley of the St Lawrence and great lakes, and 6400 feet above the ocean, appears to have escaped the abrading and polishing action, all the other hills of the same group, some of them more than 5000 feet high, having their summits visibly worn. The scratches upon the rocky surface do not radiate from the high mountain centres any more than do the materials which cover them; but they maintain, throughout New England, Pennsylvania, and the great plain west of the Appalachians, a very general average direction towards the S.S.E., or in the direction of the maximum slope of the continent. This course is most constant upon the open plains, high table-lands, and mountain-crests, but within the valleys, and at the base of the ridges, a deflection is observable; and the new direction imparted is constantly such as a moving fluid or plastic mass would take in sweeping round or past the obstructing barriers. The striæ present a general parallelism in direction; but wherever the rocky surface is uneven, they exhibit likewise a considerable deviation from one course, later grooves crossing earlier ones at various acute angles, some of which amount to 30°.

PLEISTOCENE FOSSILIFEROUS CLAYS AND SANDS.—From the coast of Maine westward to the basin of Lake Ontario, and from the estuary of the Hudson northward to that of the St Lawrence, a deposit of blue clay and sand occupies the valleys of many of the rivers and lakes at all elevations above the tide, and to a height of more than 400 feet in the valley of Lake Champlain, where its elevation is at a maximum. In the great valley occupied by Lake Champlain and the tidal portion of the Hudson, this stratum consists chiefly of a tenacious blue clay, with some beds of argillaceous sand towards its lower limit; and the same clayey character belongs to the formation which fills at a lower level the estuaries of the Connecticut, the Kennebeck, the Penobscot, and the St John rivers. In the valley and estuary of the St Lawrence the prevailing materials are sands and very sandy clays. Both the blue clay of Lake Champlain and of the Atlantic rivers, and the more sandy beds of the St Lawrence, contain marine shells; in some localities, in great abundance, about twenty-three species having been identified. All of these, without exception, are forms now living either on the coast of Massachusetts or in the Gulf of St Lawrence, and are not therefore peculiarly sub-Arctic forms. The two most generally diffused species are the *Saxicava rugosa* and the *Tellina Greenlandica*, both of which are now abundant in Massachusetts Bay. It would appear that this stratum, having its maximum present elevation above the sea-level in the district of Lake Champlain, declines gradually in height both southward and north-eastward. Its mean level in the plain of St Lawrence, at Montreal, is only about 200 feet, though some of its materials, displaced and redeposited, probably by the inundation which accompanied the uplifting and draining of the valley in which it was accumulated, are found lodged in small patches at considerably higher levels in the recesses of the bordering hills, particularly on the Montreal Mountain.

This marine Pleistocene formation has been appropriately named by E. Desor the Lawrentian Clay.

FRESH-WATER PLEISTOCENE OF THE WESTERN STATES.—An extensive deposit occurs south of Lake Erie and Lake Michigan, and in the peninsula between them, which is probably nearly contemporaneous with the marine Lawrentian; for like it, it rests generally upon the continental or general boulder-drift. It contains a few lacustrine shells, and fragments of leaves and wood, and seems to have been accumulated, like the Lawrentian formation, in the period of quiescence which intervened between the close of the great first drift-deposit and that later or last disturbance of the levels of the land which uplifted the Lawrentian, and at one and the same time drained the tidal valleys and straits in which it was collected in wide spaces around the present lakes. These freshwater beds seem, in part at least, the products of swamps and lake margins. Covered as they are very generally by superficial sands, and even a sparse strewing of boulder gravel, they appear to belong to the middle Pleistocene era, or the period of repose which separated the convulsed epochs of the earlier general and the later local drifts.

LATER LOCAL DRIFT.—In the valleys of the Hudson and Lake Champlain, and elsewhere, the Pleistocene marine clay is covered to a shallow depth with a stratum of drift composed of coarse sand, gravel, and boulders, resting on its denuded and trenched surface. No one general direction or northern source can be assigned to this upper deposit, its gravels and erratic blocks appearing rather to be derived from the more ancient general drift of the adjoining hills, redispersed by some aqueous movement upon the surface of the fossiliferous clays and sands. A similar superficial drift-like material, including in some districts erratic boulders of large dimensions, will be found to overlie very generally both the marine and the western lacustrine middle pleistocene deposits. A ready explanation of the origin of this newest pleistocene deposit suggests itself when we consider the nature and energy of the crust movements which lifted the Lawrentian clays and sands to a height, in one locality at least, of not less than 500 feet, and which drained wide tracts of the upper Lawrentian lakes. The mere agitation or pulsating movement of the crust would, if unaccompanied by any permanent uplift of the land, suffice, we would think, by lashing the waters of the tidal estuaries in one quarter, and of the lakes in the other, to strew a portion of the older drift bordering all those basins in wide dispersion upon the top of the more tranquil sediments; but if such a pulsation of the crust were accompanied with successive paroxismal liftings of wide tracts of the land, then the inundation would take the form of stupendous currents, the strewing power of which would be adequate to any amount of superficial transportation, even to the remote transportation of the largest erratics.

SECTIONS.

To assist the elucidation of the Geology of the United States, two Geological Sections are presented—one accompanying the Geological Map (Plate VIII.); the other, the Orographic Map of North and South America (Plate VII.)

The first of these, following the line A B, represents the general features of the stratification across the entire continent, from the mouth of the Chesapeake Bay to Trinidad Bay on the Pacific. The second exhibits more in detail the geological structure of the Appalachian chain, with the Atlantic slope to the south-east, and the plains of New York on the north-west. This section, pursuing the line C D, extends from the coast of New Jersey, at Egg Harbour, to the mouth of the Niagara River on Lake Ontario.

In the construction of these Sections the vertical and the horizontal scales have been kept as nearly equal as possible, only a trivial increase of the mountain elevations being allowed where this would contribute to distinctness, without in any way impairing the accuracy of the structural relations of the parts. The true angles of dip, and the real conditions of flexure of the strata, have thus been faithfully preserved.

HISTORY AND LITERATURE OF GEOLOGICAL RESEARCH IN THE UNITED STATES.

The earliest systematic examination of the geology of the older Atlantic States, resulting in a map and memoir, and describing with approximate truth the outlines of the principal divisions of the strata as they were then recognised, was by William Maclure, who presented his labours to the American Philosophical Society at Philadelphia. He traced with considerable accuracy the western boundary of the tertiary deposits of the tide-water plain from Long Island to Georgia—not recognising, however, the geological age of the strata, but calling them all Alluvium. He also defined, though more generally, the north-western limits of the then called Primary rocks, or the south-eastern boundary of the ancient secondary formations.

PALÆOZOIC FORMATIONS.—In Middle and Western New York, Professor Amos Eaton first traced with success many of the principal formations of the older Palæozoic rocks, then styled Transition and Secondary, from the Hudson River to Lake Ontario and Lake Erie. In the progress of this investigation he recognised, described, and indicated, stratigraphically and by their fossils, many of the principal formations, since more accurately and fully studied by the geologists of the New York Survey.

About the year 1830, Mr Richard C. Taylor, an English geologist cultivating the profession of a mining engineer in Pennsylvania, explored a portion of the coal-fields of that State; and between that date and 1835 published two or three papers on the subject.[1] Following the prevailing doctrine of the day, he represented the anthracitic coal-measures as more ancient than the bituminous coal strata of the Alleghany Mountain, and fell into the error of considering the rocks of this chain as resting unconformably upon those of the valleys and ridges of the Appalachian Mountains south-east of it. But he made a real step in advance in recognising in the Great Red Sandstone formation of the Alleghany Mountain the equivalent of the Old Red Sandstone of Great Britain.

Between the years 1837 and 1840, Professors H. D. Rogers and W. B. Rogers published in their annual Reports of the State Geological Surveys of New Jersey, Pennsylvania, and Virginia, their views of the structure of the Appalachian chain, explaining the remarkable phenomena of a great prevalence of south-easterly dips, and of newer strata passing under older ones, solving the enigma of a seeming inversion of the formations throughout large tracts of that chain and of the Atlantic slope, by proving in detail the dependence of these features on an oblique folding of all the strata with pressure from the south-east towards the north-west. In 1841 they applied this law of plication, with inversion of the rocks, to explain the anomaly of apparent unconformity and inversion in the Taconic and Hoosic Mountains, unravelling in a general way the geological structure of Western Massachusetts and the adjoining district of New York, and proving that the strata there are not as old as previously supposed, but are folded and highly altered outcrops of the ancient Appalachian formations as new as the Hudson River Slates.

In 1845 the same observers, after studying the crystalline masses of the White Mountains of New Hampshire, showed that some of the supposed gneissic strata of that district are but altered forms of the same older formations of the Palæozoic system. Since 1851, Professor H. D. Rogers, revising the geology of Southern Pennsylvania, has recognised in the formations previously referred by himself and others exclusively to the gneissic or primary metamorphic group, a development of the Primal and Auroral Appalachian Palæozoic strata, and has shown that a large portion of the so-called primary schists of the Atlantic slope, extending through Southern Pennsylvania, Maryland, Virginia, and even farther south-westward, are in all probability only the same Primal and Auroral strata, greatly altered and disguised by folding, crystallisation and cleavage, through the agency of prolonged and intense heat. In the same manner the metamorphic rocks to the northern part of the chain of the Green Mountains, and their prolongation towards the peninsula of Gaspé, have been detected by the Government Canadian Geologists to belong to the older and middle Palæozoic periods. Between the years 1837 and 1840 the Geological Surveyors of New York, through a systematic Palæontological and Stratigraphical investigation, conducted with much care, made known all the minuter subdivisions of the Appalachian strata as they are developed in that State. The Palæontological portion of this survey has contributed, and is still producing, very important materials towards a complete knowledge of the Palæozoic fossils of Eastern North America.

The Carboniferous rocks of the Appalachian chain, since 1836 carefully studied by Professors H. D. and W. B. Rogers, have been investigated in much detail by the former during the past seven years in Pennsylvania. Those of Nova Scotia have been chiefly explored by Gesner and Dawson.

JURASSIC AND TRIASSIC STRATA.—The Red Sandstone belts of the Connecticut valley, and of the middle and southern sea-board States, were represented by Maclure as the equivalents of the European Old Red Sandstone. H. D. Rogers, in 1836, in a report on the geological survey of New Jersey, proved these rocks to be of a later age than the true coal-measures of Pennsylvania, and referred them to a middle secondary epoch. These middle secondary red sandstones, studied in Virginia by W. B. Rogers, were shown by him, upon the evidence of a few fossils, to be referable probably to the age of the European Trias.[2] From similar evidence, the same observer, about the same time, proved that the coal-bearing rocks of Eastern Virginia are closely related by their organic remains to the earliest deposits of the oolite formation of Great Britain, and assigned them a position at or near the base of the great Jurassic system. Later researches in the same field, founded on the study of more fossils, have led him to ascribe very nearly the same date to the previously supposed Triassic rocks of the Atlantic slope.[3] Reports have reached us of the discovery of Jurassic and Triassic strata at the eastern base of the Rocky Mountains, but the evidence hitherto presented on this subject seems not to be satisfactory. The recent interesting announcement by Sir E. Belcher of Jurassic reptilian remains (*Ichthyosaurus*), having been met with in Arctic America, implies that true Jurassic rocks may exist on the western side of the great cretaceous basin.

CRETACEOUS STRATA.—The cretaceous formations so largely developed in the United States, were first recognised by Say, Conrad, and Morton, the latter describing a number of their organic remains from the State of New Jersey as early as 1834, again in 1842. The presence of these rocks upon the Upper Missouri was determined by Thomas Say. In 1834, Professor H. D. Rogers presented an outline of the cretaceous rocks, as far as they were then recognised, in a report to the British Association, and in 1837 he published a more full account of those of New Jersey, in his report on the geology of that State. The general limits, with a number of the fossils belonging to this formation in Texas, were described by F. Rœmer in 1852.[4] Notes on the organic remains found by recent exploring expeditions in Texas, New Mexico, and Nebraska, have been recently (1854-5) published by Conrad, Hall, and others. Professor Tuomey, in his description of the geology of Alabama, has traced the boundary in that State between the upper and lower divisions of the cretaceous group.

TERTIARY FORMATIONS.—The earliest exact researches into the Tertiary geology of the United States were made by Vanuxem, Say, Conrad, and Morton, who studied and described some of the tertiary fossils of Maryland and Carolina between the years 1828 and 1834; Mr Conrad pursued this branch of American geology by extending his examinations into other States, with much success, during subsequent years, even to the present time. The Tertiary strata of Virginia were explored and described, in 1834, by W. B. and H. D. Rogers. These formations, in portions of the southern and south-western States, were visited by Sir Charles Lyell in 1845, and clearly described by him. Those of Carolina and Alabama have also been carefully explored and reported upon by Professor Tuomey in Government geological reports. This geologist, in conjunction with Mr Holmes, is now publishing elaborate descriptions of the Tertiary and other fossils of South Carolina.

Upon the western side of the Continent the Tertiary strata were first distinctly recognised by J. D. Dana, in his Geology of the United States Exploring Expedition. They were further examined in 1850 by P. T. Tyson, while, more recently, in 1854, they have received much careful study from W. P. Blake, who, in connection with Government topographical surveys, has succeeded in mapping the limits of the different Tertiary formations throughout a large district in Southern California. Submitting his fossils to T. A. Conrad, the best American authority, Mr Blake proves in his reports that the Californian slope of the continent contains all the great subdivisions of the Tertiary system which were previously recognised along the Atlantic sea-board.

The Pleistocene or Quarternary deposits of the St Lawrence, Lake Champlain, and other eastern valleys of the United States, first locally studied by Bayfield, Emons, Mather, Jackson, and others, were first correctly placed in relation to the other tertiaries and the drift, by Professor E. Desor.[5] The recognition of Pleistocene deposits in California is due chiefly to W. P. Blake.

The fresh-water drift of the districts bordering the Lawrentian lakes was first distinctly recognised, and has been most fully studied, by Mr Whittlesea.

MAPS AND MEMOIRS CONSULTED IN THE CONSTRUCTION OF THE MAP.

Map and Report of Geology of Newfoundland, by J. B. Jukes, F.G.S., 1843. Map of Geology of Nova Scotia, by Messrs C. F. Jackson and F. Alger, 1833. Map of Geology of Nova Scotia, by Dr A. Gesner, 1843. Local Maps and Sections of Nova Scotia, Cape Breton, and Prince Edward Island, by J. W. Dawson, Esq., 1842-1853. Acadian Geology, by J. W. Dawson, 1855. Geological Map of North America, by Sir C. Lyell, 1845. Statistics of Coal Maps and Sections of American Coal-Fields, by R. C. Taylor, F.G.S., 1848. Geological Map of New Brunswick, by Professor J. F. W. Johnston. Maps and Descriptions of Geology of Canada, by Dr Bigsby. Reports and Map of Geology of Canada, by Sir W. E. Logan, F.G.S. Map and Description of North America, by Sir J. Richardson. Report of Geology of Lake Superior, by Messrs Foster and Whitney. Maps and Reports of States of Maine, Rhode Island, and New Hampshire, by Dr Charles F. Jackson. Reports of Geology of Massachusetts, by Professor Hitchcock. Reports of Geology of Connecticut and Vermont, by Rev. Zadock Thomson, Professor Adam, Professor C. U. Shephard, and Dr F. G. Perceval. Reports of Geology of New York, by Messrs Emons, Hall, Mather, and Vanuxen. Reports of Geology of New Jersey and Pennsylvania, by Professor H. D. Rogers. Geological Maps of Maryland, by Professors W. B. and H. D. Rogers, Professor Ducatel, and F. A. Conrad, Esq. Geological Report of Delaware, by J. C. Booth, Esq. Geological Reports of Virginia, by Professors W. B. and H. D. Rogers. Geological Map of North Carolina, by Elisha Mitchell, Esq.; and Map by T. A. Conrad, Esq., 1842. Geological Reports and Map of South Carolina, by Professor Tuomey, 1845. Report and Map of Geology of Alabama, by Professor Tuomey. Report and Map of Geology of Alabama, by T. A. Conrad, Esq. Map of the State of Mississippi, by Oscar M. Lieber, 1854. Geological Map of Louisiana and Texas, by Dr Roemer. Geological Reports of Eastern Part of Ohio, by Messrs Locke, Mather, Briggs, and Foster, 1837-8. Geological Map of Western States, by Byram Laurence, Esq. Geology of Illinois (unpublished), by Professor D. Norwood. Geological Survey of Illinois, by Dr Douglas Houghton. Reports of Geology of Michigan, by Dr C. T. Jackson, 1850. Reports of Geology of Michigan, by Messrs J. W. Foster and J. D. Whitney, 1850-1. Reports of Geology of Indiana, Iowa, Wisconsin, Minnesota, and Nebraska, by Dr D. D. Owen, 1852. Reports of Geology of Kentucky, by Dr D. D. Owen, Dr Norwood, Professor A. P. Yandell, and B. F. Shumard. Report of Geology of Tennessee, by Professor G. Troost, 1840, and Professor Safford. Information regarding the Great Western Plains, Rocky Mountains, Oregon, Utah, &c., by Lewis and Clark, Colonel Long, Captain Bonneville, Parker, Bryant, &c. Reports and Maps of Nicolai, 1843; Captain Fremont, 1843; Major Emery, 1848; Lieutenant Abert, 1843; A. Weslezenus, Cooke, Johnston, Simson. Captain Stansbury's Survey of Utah Salt Lake, 1852. Captain Marcy's Exploration of the Red River, &c., 1852. Captain Sitgreave's Account of the Zuni and Colorado Rivers, 1854. Geology of Oregon, by J. D. Dana, Esq., in Captain Wilkes's Exploring Expedition. Geology of California, by Jules Marcou, W. P. Blake, Esq., and Dr J. B. Trask, 1854-5.

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[1] Trans. Geol. Soc. of Pennsylvania.

[2] See Trans. Amer. Ass. of Geol., 1842.

[3] Proceedings Boston Nat. Hist. Society.

[4] Die Kreidebildungen von Texas.

[5] See Silliman's Journal.

ON
GLACIERS AND GLACIAL PHÆNOMENA.

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I. ON THE DISTRIBUTION OF PERMANENT SNOW ON THE EARTH'S SURFACE.

In the description of the Map of Isothermal Lines, the general phenomena of climatology have been glanced at. The dependence of the average annual heat of the earth's surface on the latitude was exhibited by means of curves which passed over every point possessing the same mean temperature. The intervals of these lines, or the spaces corresponding to equal differences of mean temperature, are widest near the equator, and closer in higher latitudes (supposing them correctly represented on a spherical surface); they do not follow the parallels of latitude with accuracy, but for about half the surface of the globe they approximate to them. The limits of *mean* yearly temperature which have been satisfactorily observed vary between 84° or 85° Fahrenheit, and 0° of that scale (+ 29 to — 18 cent.) Supposing, then, for a moment, the variation of the seasons abolished, and the mean temperature constant throughout the whole year, there would be a considerable part of the earth's surface where fresh water would be unknown in the liquid form, and where even salt water could only be obtained by piercing through an immense thickness of permanent ice. The phenomenon of rain would be unknown. The natural covering of the earth would be snow, as that of the water would be ice. Now there is an approximation to such a state of things. In certain latitudes, snow and ice are as much the habitual covering of the globe as earth and water are elsewhere, although this effect does not necessarily take place at the isothermal line of 32°, or where the mean annual temperature is at the freezing point; for the perpetuity of snow at any point does not depend on the mean temperature, but on the fact that all the thawing influences of the summer period of the year balance all the freezing and accumulating influences of the winter period.

But besides the effect of latitude, the influence of height is productive of cold; and the ascent of a high mountain between the tropics leads the naturalist, within the compass of a day or two, through the whole range of climate which months of laborious journeying towards the arctic regions would be required to exhibit. Vegetation has a similar progression in the one case as in the other (see the map illustrative of the Geography of Plants): the palm and aloe yield to the chesnut and the vine—these to the oak and beech—these again to the hardier pines—the pines to the dwarf birch and rhododendron, and these to simple grasses and lichen, till at length perpetual snow bounds the outskirt of vegetation, as well in vertical as in horizontal extension. The level of perpetual snow, which in the Cordillera of Southern America reaches the height of 18,300 feet (5,650 metres), has descended in the Alps of Europe to 8,900 feet (2,700 metres); in Norway, in lat. 60°, to 5500 ft.; in lat. 70°, to 3400 ft. For the reasons already mentioned, especially the enormous differences of temperature in the arctic regions under the same parallel of latitude, these numbers give only a very partial insight into the state of the facts. In particular, many authors have doubted whether the surface of *perpetual congelation* (as it has been commonly but erroneously called) touches the level of the sea at all. The mean temperature at the snow line near the equator is 34°.7; in the temperate zone it is 25°.3; in the arctic regions about 21°: but we have the mean temperature of Melville Island = 0° of Fahrenheit; therefore, it might be conceived to be surrounded by a vast waste of perpetual snow (see the Map of Isothermal Lines of 20°). Such a conclusion, however plausible, appears to be unsound. The best authorities agree that even in the most rigorous polar climates of the Northern Hemisphere, the extreme dryness of the climate, and the perpetual day of summer, occasion the complete disappearance of the snow in level positions, which gives place to positive vegetation suitable for the support of arctic animals. In the antarctic regions, however, the line of perpetual snow at the sea level is reached between 67° and 71°;[1] the difference probably arising from the greater humidity of the atmosphere there. The complete disappearance of the snow fallen in winter is a complex phenomenon, and cannot be expected to follow any simple law, or to be regulated by the mere geographical position. It depends, for example, as much upon the depth of the fall of snow as upon the heat of the summer, and very much upon the prevalent winds, and upon the exposure. Hence, even on the same group of mountains, the snow level varies greatly. In the Alps it is probably 700 feet lower on the northern than the southern side, whilst in the Himalaya range, by a singular inversion (which we cannot here stop to explain), it is about 3,000 feet higher on the side of Tartary than towards Hindostan.

Thus the limit of perpetual snow over the globe is bounded approximately by a spheroidical surface flatter than the terrestrial spheroid, and cutting it in the vicinity of the poles.[2] Thus also the habitable earth is bounded in all directions by regions which appear to be designedly rendered inaccessible, just in proportion as they are incapable of supporting human life. The polar regions are guarded by the bulwarks of their inhospitable climate, where "winter barricades the realms of frost." Were a large portion of the earth's surface situated at a higher level than it is, it would be placed beyond the uses or occupation of man, whose physical powers fail as the increasing rigour of the higher atmosphere renders his maintenance impossible. And even if he were to seek emancipation from the boundaries of his mortal prison in the depths of the earth, the increasing temperature of his mines opposes a not less impassable obstacle to the enlargement of his domain in that direction.

The portion of the earth's surface under perpetual snow has never yet, we believe, been estimated. The most conspicuous masses, next to the antarctic regions, are the Cordillera, the Himalaya range, the Altai and Ural, and the Alps; but from the steepness of most elevated summits, and the absolute want of *very* elevated table-lands (see the article on the Mean Height of Continents in the Physical Atlas), the area they present is inconsiderable.

From the variable elevation of the snow line, the snow-clad portions of mountains are very disproportionate to their height in different latitudes. Chimborazo, in Peru, so long supposed to be the highest mountain in the world, rises only 5,600 feet above the snow line; whilst Mont Blanc, in Europe, of which the absolute height is 6,000 feet less, is covered with perpetual snow for the upper 7,000 feet of its elevation. The Himalaya, indeed, whose heights have till lately been considered almost fabulous, but which are now well ascertained, in several instances, to exceed 25,000 feet, rise 9,000 above the snow line on their southern, and more than 12,000 feet above that on their northern slope. The only parallel for this prodigious elevation above the snow line is singularly enough presented by one of the most striking and unexpected of modern geographical discoveries, Mount Erebus, an active volcano, rising 12,000 feet above the ever-frozen shore of the Antarctic Sea, within 15° of the pole, which, all unseen by man, has vomited for thousands of years its fiery flood, amidst the unbroken solitude of that frozen wilderness, until discovered by Sir James Ross in 1841. These relations of the snow line are fully illustrated in the Plate, fig. vi.

On this subject space only allows me to add, that the height of the snow line depends materially on the extent of snow-clad surface rising above it; an extensive snow-capped chain or group of mountains lowering the level of perpetual snow, whilst an isolated summit may rise above the level of the theoretical snow line without retaining the snow for the whole year. Thus the volcano of Mouna-Roa, in Owhyee (latitude 20° north), though it attains a height of 15,900 feet, does not reach the snow line. Perhaps, for the same reason, the highest mountains of Scotland do not reach the true snow line, although snow often lies for the whole year in shady places.[3]

II. GLACIERS.

It is now time to distinguish, more particularly, one of the most peculiar features which often though not invariably, accompany perpetual snow—I mean the existence of glaciers.

A glacier, in the most correct meaning of the term, is a mass of true ice, possessing hardness and transparency, which, descending below the usual snow line, prolongs its course down the cavity of one of those vast gorges which furrow the sides of most mountain ranges. Any one who is placed so as to see a glacier in connection with the range from which it has its origin, at once infers that it is in some sense or other the outlet, or rather the overflow or *waste*, of the vast snow fields which occupy the higher regions. It may be compared not unaptly to an icicle descending from a snow-covered roof; and its magnitude is usually exceedingly small compared to the extent of the snow fields whence it draws its origin. There seems, indeed, to be a well established connection between the one and the other, such as necessarily subsists between the area of drainage of a valley and the size of the stream which flows through it. A small or single valley has a puny rivulet; but if it divide into extensive ramifications, and its springs spread over a large mountain district, a large torrent is the result. Hence, a glacier being a peculiar prolongation of the limit of perpetual snow, under peculiar circumstances, its boundary is by no means determined by anything like the snow-plane in any country. The mere existence of it in a position where we know that waste must predominate over supply, proves that it has a motion bodily downwards, which repairs the extraordinary waste to which it is subjected, by intruding its gelid mass into the inhabited and cultivated valleys.

III. THE INFERIOR LEVEL OF GLACIERS

depending upon partial, not general phenomena—on the quantity of ice compared to the surface which it exposes to the thawing influences, on the exposition of its valley, and other circumstances—is exceedingly irregular. Thus, though the snow line in the Alps does not commonly descend below 8,600 English feet, the Lower Glacier of the Aar descends to the level of 5,900 feet, that of Rosenlaui to 5,100 feet, the Upper Grindelwald Glacier to 4,300, the Lower Grindelwald Glacier to 3,400, whilst the source of the Arveiron at the base of the Glacier des Bois, in the Valley of Chamouni is about 50 feet higher.

This protrusion of the icy mass to a lower level than the snow line is a phenomenon depending apparently upon its consistence. If the theory which we shall, in the course of this article, endeavour to explain, be correct, the meteorological conditions which produce a highly liquefied, *sludgy* state of the accumulated snows, are the most favourable to the production of glaciers, and to their progress into the valleys, by producing a certain ductility of parts which enables them to overcome obstacles otherwise insurmountable. But be this as it may, it is certain that the meteorological conditions of the temperate regions develop the growth of glaciers more than those of either polar or tropical regions.

IV. GEOGRAPHICAL DISTRIBUTION OF GLACIERS.

ASIA.—It was long believed that no glaciers exist in the Himalaya. Their discovery is in fact quite recent. This is, however, due to the fact that the earlier travellers erroneously described them as *snow beds*. Thus Mr Baillie Fraser[4] describes the source of the Ganges as occurring in a semicircular hollow of very considerable extent, formed by five principal peaks, and filled with eternal *snow*, from the gradual dissolution of which the principal part of the stream is generated. A little farther north, on the declivity of the Himalayan range, towards Chinese Tartary, and in the mountains of Kouenlun, the glacier formation is well developed; and it will be recollected that it has been already stated, that, upon that slope of the great Asiatic chain, the snow line is some thousand feet lower than upon the side of Hindostan. The glacier of the source of a tributary of the Indus, in Little Tibet, in latitude 35° 40′, is thus unequivocally described by Mr Vigne, in his travels through Kashmir :—

"But the glory of the valley is the magnificent glacier at the end of it. Its lower extremity is a short distance from the village of Arindo, and the natives say that it is slowly but perceptibly advancing. It occupies the entire valley, as far as the eye can reach, and a place that looks more like the extremity of the world does not exist in nature. Vast mountains, alike bare, precipitous, and rugged, appear to form a channel for it, and, in the extreme distance, their sides are coloured with the red and white tints of iron and gypsum. The width of the lofty wall of ice, in which it terminates towards Arindo, is about a quarter of a mile; its height is nearly 100 feet. The only way in which I can account for the quantity of soil and rock upon its upper surface (on which I gathered several plants), is, that it must have been collected partly by the effect of winds, and partly by the avalanches of ages past, which fell upon it, and deposited a detritus, when as yet, from the narrowness of its bed, it was more within range of their descending forces. I have never seen any spectacle of the same nature so truly grand as the debouchure of the waters from beneath this glacier. The ice is clear and green as an emerald; the archway lofty, gloomy, and Avernus-like. The stream that emerges from beneath it is no incipient brook, but a large and ready-formed river, whose colour is that of the soil which it has collected in its course, whose violence and velocity betoken a very long descent, and whose force is best explained by saying that it rolls along with it enormous masses of ice, that are whirled against the rocks in its bed with a concussion producing a sound resembling that of a distant cannon, and, if not permanently intercepted by them, may be seen floating on the Indus, even below the Valley of Iskardo."[1] In other parts of the same volume the mention of glaciers is frequent, and they are marked in his map as occurring in the district of Kashmir, in as low a latitude as 34° 15′.

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[1] Private Letter of Sir James Ross.

[2] Astronomers have ascribed a peculiarly luminous appearance, near the poles of the planet Mars, to the existence there of perpetual snow and ice.

[3] "Sir Henry Munro holds a forest from the crown by a very whimsical tenure—that of delivering a snow ball on any day of the year that it is demanded; and he seems to be in no danger of forfeiting his right by failure of the quit-rent; for snow lies in the form of a *glacier* in the chasms of *Bennewish*, a neighbouring mountain, throughout the year."—*Pennant's Tour in Scotland*, 4to, i., 185. Ben Wyvis is in latitude 57° 40′ north.

[4] Ed. Phil. Journal, i., 127.

More recently, the glaciers of Northern India have been explored by Major Madden, Captain Richard Strachey, Drs Thomson and Hooker, and Mr Winterbottom. The inferior limit in point of latitude is probably between 27° and 28° North, where they come down to the level of 13,000 feet. In latitude 30½°, longitude 80° East, is the remarkable glacier of Pindur, which has been described, and its motion measured, by Captain Richard Strachey. Its inferior level is 12,000 feet. Dr Thomson mentions a very fine glacier at Parang, latitude 32¼°—and one of prodigious size, probably the largest in the world yet described, on the north side of the Bardar or Umasi Pass, in latitude 33° 20′, longitude 76½° East. In latitude 36° glaciers descend to 9,000 feet. The number of the Himalayan glaciers is evidently immense, and they resemble in all essential particulars those of Europe.

In the Altai, glaciers are rare; one, however, the Katunj Glacier, has lately been distinctly described.[2] It descends from the Mountain Bjelucha, the Russian Altai (11,000 feet), and is a mile and a half long. In the Caucasus the existence of glaciers may be considered as still uncertain. It is doubtful whether the Ural reaches the limit of perpetual snow.

In the tropical regions of America, notwithstanding the vast height and extent of the Andes, we have the positive assurance of Von Humboldt[3] that no glaciers occur. This he ascribes, with probability, (1) to the extreme steepness of most of the snow-covered peaks (which is well borne out by the figures in his *Atlas Pittoresque*), and (2) to the excessive dryness of the air in these elevated regions, which prevents any softening of the snow by infiltrated water. To these reasons may be added a third, suggested by M. Elie de Beaumont, that the annual changes of temperature are trifling, and penetrate but a small way into the snowy masses.

EUROPE.—In Europe glaciers attain a most perfect development in the great chain of Alps, the Pyrenees being nearly destitute of true glaciers, although rising far above the limits of perpetual snow, but throughout very limited spaces.

The most southern part of the Alps with which I am acquainted, where true glaciers occur, is the Chain of Mont Pelvoux, in Dauphiné, under a latitude somewhat less than 45°. There are no glaciers surrounding Monte Viso. The Po takes its rise in a frozen lake amidst beds of snow. The principal glacier groups of the Alps are:—

1. Group of Mont Pelvoux. 2. Mont Iseran, with vast branches extending eastwards towards Cogne, northwards to the Ruitor, westwards to the Aiguille de la Vanoise. 3. Mont Blanc. 4. Mont Velan. 5. Monte Rosa. 6. The Bernese Alps. 7. The St Gothard. 8. The Bernardin. 9. The Bernina. 10. The Ortler Spitz and Oetzthal. 11. Venediger Spitz, and the Gross Glockner. Eastwards of this, unless in the small group of Hallstadt, glaciers do not occur.

We shall return to the glaciers of Switzerland, and give a more detailed account of some of them. In the meantime, to continue the picture of the glacier formations in different geographical regions, we shall quote from Captain Basil Hall's faithful and lively sketch of the Glacier of Miage, near Mont Blanc:—

. . . . . "The most remarkable is the Glacier of Miage, which not merely comes all down the side of the mountain, but actually traverses the valley at right angles, dams up the stream flowing along it, and by a long series of deposits of broken rocks, the detritus of the higher ridges of the Alps, forms a huge rampart across the valley, several hundred feet high. Above this mighty natural barrier is collected the Lake of Combal, the waste waters of which have no small difficulty in finding their way past this formidable impediment. They are drawn off by a narrow channel lying between the mountains on the south side of the Allée Blanche, and the end of the embankment of rocks deposited by the glacier. It will readily be understood, that when a glacier, such as that of Miage, though originating in the cold regions at the top, forces its way down to the warm climate of the valleys, all that part of it which consists of ice and snow, when it reaches so far, must, in process of time, be melted. But in so doing, as the huge *moraines*, or embankments of broken rocks lying on the top of the glacier, cannot be got rid of in this way, they fall down in confused heaps, as soon as the ice which supports them disappears. Moreover, it will be apparent, that as the glacier brings down a fresh supply of similar materials every season, and as a considerable portion of these fragments are disengaged every summer by the ice melting, such an accumulation must in time take place as makes the imagination of any one but a stout-hearted geologist giddy. I am acquainted with only one other scene in the world which can pretend to rival, in natural magnificence, the Glacier de Miage; I mean Niagara, which is, no doubt, even more simple in its grandeur; and being far more beautiful upon the whole, is more pleasing as an object of contemplation. The Glacier of Miage has no pretension to beauty; it is a sort of monster whose magnificence is due chiefly to its enormous size, and the savage variety of its structure, coupled with its utter incongruity with the surrounding scenery."[4]

We must here observe, that though the existence of glaciers protruding below the snow line into the warm valleys seems to render it impossible to fix with any accuracy the limit of "perpetual snow," this is not really the case. The snow line is as well marked on a glacier as elsewhere—according to some authors, better. Beneath the snow line *the winter snow melts as regularly and as completely* (with insignificant exceptions) *upon the surface of the ice as of the soil*. The glacier, therefore, does not grow by its upper surface. But in the higher regions (above 8,500 or 9,000 feet in the Alps) the winter snows accumulate—more falls than melts—the glacier is in a state of perpetual accumulation, and has, consequently, a continually fresh snowy surface composed of layers. This part of the glacier is called the *névé* in French, and *firn* in German Switzerland.

As we approach the poles, the glaciers assume more and more the character of *névé*. In Scotland, though the mountains do not attain the proper snow line, masses of snow often remain unmelted in sheltered hollows; and Colonel Colby of the Ordnance Survey has informed me that he once for curiosity, caused workmen to dig into one of these old snow beds in such a cavity, on the mountain of Lochnagar, in Aberdeenshire, and he found the lower part converted into ice. Were this phenomenon not merely local, arising from an excessive accumulation of snow over one spot, it would be a true *névé*.[5]

NORWAY—ICELAND.—In Norway the glaciers are numerous, though as yet little visited. The first met with are the Folgefonden, in latitude 60°, near Bergen; but they attain their greatest development at Justedal, about a degree farther north. The glaciers of Nygaard and Lodal[6], belonging to this group, strikingly resemble those of the Alps. One of the glaciers of Fjærland, in the same region, approaches within 150 feet of the sea-level. The next great glacial group is that of Fondal, near the sea, just within the Arctic Circle. Sulitelma, in latitude 67°, is a vast snow-covered mountain on the borders of Norway and Lapland, which presents true glaciers, admirably described in 1808 by Wahlenberg, the De Saussure of the north. Some glaciers, but of less extent, occur on the coast of Norway as high as 70° 20′. One of these, in the Jokulsfiord, descends *into* the sea. The interior of Iceland is covered with glaciers, two of the finest of which are Swinafells-Jökull and Holaar-Jökull. The Island of Jan Mayen, in latitude 71°, contains numerous glaciers, there called icebergs, thus described by Scoresby: "They occupy recesses in the cliff where it is 1,284 feet high, and nearly perpendicular, and extend from the base of Beerenberg (a mountain 6,870 feet high, seated on a base of 1,500 feet) down to the water's edge. These polar glaciers differed in appearance from anything of the kind I had before seen. They were very rough on the surface, and of a greenish-grey colour. They presented the appearance of immense cataracts suddenly arrested in their progress, and congealed on the spot by the power of an intense frost. Like cascades, their prominent greenish colour was variegated with snow-white patches resembling foam, which were contrasted with the jet black points of the most prominent rocks peeping through their surfaces. As in cataracts, also, they seemed to follow in some measure, the figure of the rocks over which they lay, and were marked with curvilinear striæ [probably *moraines*] from top to bottom."[7]

SPITZBERGEN.—The glaciers of Spitzbergen, which are highly interesting, from their extreme northern position, touching probably the line in which perpetual snow reaches the sea level, have been described by several authors, and most recently by M. Martins,[8] who has compared them with the glaciers of the Alps. The very best idea of them may, however, be formed from the excellent old engravings in Phipps' Voyage,[9] and the descriptions of Scoresby,[10] leave little to desire; want of space alone prevents us from quoting these. The largest iceberg or glacier he saw presents a frontage of eleven miles to the sea, with a cliff 400 feet high, and it extends backwards towards the mountain tops, to a height about four times as great. The truncation of these icy masses, by the action of the sea, produces the ice islands or floating icebergs, so frequent in the arctic seas, and especially in Baffin Bay. Occasionally these glaciers project their snout into the sea to a great distance, without being broken off, and possess so much flexibility that Sir James Ross informs me that they rise and fall with the tide, to a certain extent, so that the apparent tidal variation is diminished to one half, at the extremity of such protruding glaciers.

SOUTH AMERICA.—In the Southern Hemisphere, true glaciers appear to commence on the west coast of Patagonia, and reach to the sea, in latitude 46° 40′, and are numerous in Teirra del Fuego, of which an excellent account has been given by Captain King and Mr Darwin.[11] The south polar continent is almost everywhere guarded by mural precipices of ice of great extent.[12]

Such being a brief sketch of the distribution of glaciers over the globe, we shall proceed to illustrate this subject further by special reference to the topography of glaciers in the Alps, being the region where not only they are most accessible, but where, likewise, they are best developed.

V. GLACIERS OF THE ALPS.

The extent of these is estimated by Ebel[13] at 130 square leagues, equal to about 1,400 English square miles, and their number at 400. They form the source and feeders of many important rivers, especially those which take their rise on the north side of the chain, such as the Rhine and Rhone, each of which flow from glaciers bearing their name. In earlier times the extent of perpetual snow in Switzerland appears to have been much exaggerated, and a notion which, with our present knowledge of geography, seems highly absurd, prevailed—that all the glaciers of Switzerland had their origin in a common expanse of snow and ice, called a Mer de Glace, by which they were reduced, as it were, to one. Places inaccessible, and viewed from only one side, valleys and chains never ascended or crossed, became invested by the imagination with unreal magnitude; and if we consider the enormous circuits required to visit in succession the glaciers descending from any mountain range in Switzerland, we cannot wonder that common notions of space and distance, unaided by trigonometry, should have been confounded, and a snowy connection presumed between points the most remote, which had only been visited, so to speak, circumferentially. The task of ascending mountain summits is of recent growth, and perhaps its chief benefit to the science of physical geography has been, by enabling the eye, tutored to accurate and comprehensive observation, to seize the totality of complex relations of mountain chains, of geological formations, and of glaciers.

It appears, that so late as 1776 the distinguished Swiss botanist, Haller, found it necessary in his preface to "Wagner's Views in Switzerland," now before me, to refute the idea, that the whole Alps formed a united snowy mass or *Mer de Glace;* and quotes, in proof of the discontinuity, passages like the Grimsel and the Gemmi, which in summer are altogether clear of snow.

Nevertheless, there is some truth in the view, that in local groups or individual mountain masses, there is a central accumulation of snows which form the *pabulum* or nutriment of the descending glaciers. These two parts of the common system have been named by some authors "Glaciers Reservoirs," and "Glaciers d'Ecouelment."

These groups or glacier masses have been enumerated, at least the principal of them. The two most considerable in the Alps are those of Monte Rosa and its dependencies, and of the Finsteraarhorn and its dependencies. The greatest glacier in Switzerland is probably that of Aletsch, which belongs to the latter of these systems, originating at the northern slope of the Jungfrau, and extending nearly to Brieg in the Vallais, a distance (as nearly as we can judge) of fourteen English miles, with a breadth of one and three fourth miles in some places, and uniting the icy contributions of many vast tributaries.

It will conduce to a fuller understanding of the whole circumstances and phenomena of Alpine glaciers, and contribute to the knowledge of their geography, with which this work is more especially conversant, if we describe topographically two or three of these groups; and we select

1. The glacier group of Mont Blanc. Fig. i.
2. The glacier group of the Finsteraarhorn. Fig. ii.

1. THE GROUP OF MONT BLANC.

This is a somewhat oval group, with its longer axis extending in a direction North 49° East, and South 49° West, thirty miles from the Col de Bonhomme to the Mont Catogne, near Martigny (not included in the map); and its transverse axis about nine miles from Chamouni to Courmayeur. It is bounded by five rivers—on the north side by the Arve; on the west by the Bounant, descending from the Col de Bonhomme; on the south by the two branches of the Doire, descending the Allée Blanche and Piedmontese Val Ferret; and on the east by the tributary of the Dranse, which descends the Swiss Val Ferret. The culminating point of the chain is Mont Blanc, the highest European mountain, being 15,744 English feet above the level of the sea, according to the latest authority of the French engineers. Its measure may be considered as varying probably to an extent of twenty feet, by the varying thickness of condensed snow consolidated into ice,[14] which forms its summit. The top is of a flattened saddle-shaped form, and has been called the *Dos d'âne*. That considerable masses of ice may exist on mountain tops, and form those tops, is certain. Near the Ortler Spitz, in the Tyrol, I have seen a mountain with a crystalline, evidently translucent, summit. The south side of Mont Blanc is very steep, and when viewed from the Allée Blanche, appears absolutely precipitous; this is very far, however, from being the case. It will be seen by the map, that from the summit of Mont Blanc to the River Doire, is a distance of about 5,500 metres, and its elevation above the river is about 3,200 metres; consequently the angle of mean altitude is 30° 11′. From the side of Chamouni it is much less, the distance being more than double, and the relative height little greater. It is from that side alone that the mountain has been, or perhaps can be, ascended. The route now commonly adopted is by following the solid ground as high as possible on the east side of the Glacier de Bossons. The glacier is then crossed, and the bold rocks called the *Grands Mulets* gained, where the first night is passed, at a height of 10,000 feet above the sea. The traveller then enters a kind of valley or indenture, in the northern slope of the mountain, filled, of course, with snow and ice, forming the feeder or *névé* of the Glacier of Bossons, and with the prominent ridge which forms a swelling promontory, called *Dôme de Gouté*, on his right. This hollow is called the Grand Plateau; and part of the traverse is dangerous, on account of the *avalanches* which fall from the high grounds on the right. After a fresh ascent, the *Petit Plateau* is attained; the traveller then turns abruptly to the left, and commences an ascent over an icy acclivity of about 30°, in which steps must be cut, till the last rocks are reached, and soon after the summit is gained, without further difficulty than what arises from fatigue and the exhaustion which the rarified air produces in many constitutions.

The snowy scalp of Mont Blanc is the point of real union of several of the glaciers of the chain. The Glacier de Bossons, as was remarked by De Saussure, is absolutely continuous from the top to the bottom of the mountain, a height of 12,300 feet. It ascends higher and descends lower than almost any other glacier in Switzerland. Its course is also excessively steep. Its mean motion I have ascertained to be very rapid. It is fed by the vast contributions of the Grand Plateau, which furnish a supply of icy material proportioned to the vast expenditure below. The largest glacier of the chain, the *Mer de Glace* (formerly called Glacier de Bayer, and it is a preferable name), does not take its origin from the summit of Mont Blanc, being divided by a rugged and impassable chain of the Monts Maudits. But the Glacier de Bionassay, which lies north-west from the summit, is probably in connection with it, occupying a chasm which extends by the Aiguille and Dôme de Gouté (see the map), as well as the Glacier of Miage to the south-west, and of La Brenva to the south-east. These four glaciers (with some embranchments, such as the Glacier of Taconnay from that of Bossons) can alone be considered as belonging to the summit of Mont Blanc. The other numerous glaciers of the chain take their rise from local accumulations of snow in the complicated systems of valleys which intersect it. The more complex and more extensive, the larger the glacier produced.

By far the largest and most complex glacier of the chain is the Mer de Glace or Glacier de Bayer, already spoken of. The lowest or terminal part, called the Glacier des Bois, gives rise to the River Arveiron, about two miles above the village of Chamouni. The Glacier des Bois is precipitous for a considerable distance, until below the châlet of Montanvert, it becomes comparatively level, having a mean slope of only 4½°, which extends for several miles upwards towards the centre of the chain, the glacier having a mean breadth of about 2,500 feet, or about half a mile. At length it divides into two branches, the Glacier de Lechaud taking its origin at the foot of the Grand Jorasse, quite in the axis of the chain, and which is swelled by the contribution of the overflow of the fine Glacier of Talèfre; and the Glacier du Géant, descending from the col of the same name, 11,146 English feet in height, celebrated as the residence of De Saussure for seventeen days, having numerous tributaries, particularly one which descends from between the Mont Blanc du Tacul, and the Aiguille du Midi. This last belongs to a peculiarly rugged chain of mountains which divide the Glacier du Géant from the valley of Chamouni, and which are called the Chain of Aiguilles (or Needles) of Chamouni. They are all inaccessible (the so-called ascents of the Aiguille du Midi not having included its highest peak), and furnish some small glaciers on both sides of their declivities. The great extent, and still greater variety of surface of this glacier, make it a condensed type of all glaciers, and admirably suited for study. Its parts may be understood from the small reduction in the plate from the large map constructed from actual survey, which accompanies my "Travels in the Alps of Savoy," to which I must refer for further details than could be suitably entered into here. The area of the basin of the mountains within which the Mer de Glace is situated may be rudely estimated at thirty square miles; but of this a large portion is rock, which does not contribute any share of its snowy covering to the increase of the glacier. Further: according to a rough and imperfect estimate, the whole *contiguous* surface of ice and snow connected with this glacier, is 17.43 square miles; of this, there belongs to the *névé*, or that part where the glacier *grows* from year to year, 12.30 square miles, thus distributed:—

	Square Miles.	
Glacier du Talèfre, névé, ...	2.57	
Névé of Glacier de Lechaud, ...	3.17	
Névé of Glacier du Géant, ...	6.56	
	——	12.30

The following portion includes the glacier proper, where the waste exceeds the supply, or the glacier *loses* matter:—

Part of the Glacier de Lechaud, ...	0.58	
Part of the Glacier du Géant, ...	1.00	
The United Glacier, ...	3.55	
	——	5.13
Total, . . .		17.43

We have here left out of account the area of numerous *small glaciers* (glaciers of the second order of De Saussure), which take their origin in the cavities of the higher rocks, but which, from deficient supply, never reach the main glacier below, and therefore cannot be considered as tributaries. They may be said to expire in the cradle. Such are the glaciers of the Nant Blanc, of Dru, of Charmoz, of Trelaporte, of the Périades, and many others—all in this one basin.

I estimated roughly, in the month of September, the discharge from the source of the Arveiron, at the foot of the glacier, at 300 cubic feet per second. This is considerably under its maximum discharge in July. In winter, the stream is very far indeed from being dry; perhaps, however, we should not be very far wrong in considering the quantity now mentioned as an approximation to the *excess of the greatest over the least discharge;* which evidently corresponds to the total fusion of the glacier and *névé* in the height of summer; since in winter the flow depends solely upon the spring water issuing from the depths of the earth under the glacier, the drainage of the glacier, and the quantity which the native heat of the earth is capable of melting from the inferior surface of the glacier.

The map, fig. iii., shows the outline of the greater part of the glacier proper, taken from my work already mentioned. Fig. ix. represents separately the Glacier of Talèfre, with the rocky islet called *Le Jardin* in the midst of it, the area of which is about 0.06 of a square mile.

We can do little more than enumerate the glaciers which present themselves in succession, in making the circuit of Mont Blanc, and serve as the outlets of the vast snowy accumulations of the chain, whose area (the area above the snow line and the glaciers together), may amount to between 90 and 100 square miles.

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[1] Vigne's Travels in Kashmir, ii., 285, 286.
[2] Leonhard's Taschenbuch, 1845.
[3] Asie Centrale, iii., 264.
[4] Patchwork, by Captain Basil Hall, i., 91, &c.
[5] See note 3, last page.
[6] See Bohr's interesting account of these mountains—Jameson's Ed. Phil. Journal, 1827, vol. iii., p. 255. He is the only author, as far as I know, who has attempted to estimate the diurnal fusion of a glacier. He supposes that above 5,000,000 of cubic *fathoms* of snow are melted into the river of Justedal during half a summer's day.—*Ib.*, p. 264.
[7] Scoresby's Arctic Regions, i. 159.
[8] Bibliotheque Universelle de Genève. Nouv. Serie. Tom. xxviii., published 1840.
[9] Published 1774.
[10] Arctic Regions, vol. i., p. 101, &c.
[11] Darwin's Voyage of "Adventure and Beagle," p. 279.
[12] Sir J. Ross.
[13] Guide du Voyageur en Suisse, *art.* Glacier. His remarks include only those from Mont Blanc eastwards.
[14] De Saussure, Voyages, § 2,015, thinks that the thickness of the snowy covering of Mont Blanc may amount to 200 feet.

1. Glacier des Bois, already described.

Omitting the small glaciers belonging to the Aiguilles, four in number.

2. Glacier de Bossons, proceeding directly from Mont Blanc.

3. Glacier de Taconnay, a branch of the preceding, divided from it by the Montagne de la Côte, by which the earlier expeditions to Mont Blanc were made. This glacier appears formerly to have been much more extended, judging from its moraine, which appears to have once crossed the River Arve, and even to have extended much lower.

4. Glacier de la Gria or du Bourget, an elegant glacier descending from the Aiguille de Gouté, terminating, however, at a great height. It is very steeply inclined, but not fragmentary. It is long and narrow, and its surface *concave*.

5. Glacier of Bionassay, a fine glacier, descending from behind the ridge of the Aiguille and Dôme de Gouté. It was in this direction that De Saussure first hoped to attain the summit of Mont Blanc, and he ascended a considerable way. (Voyages, vol. ii.) There is strong reason to think that this glacier once extended itself into the Val de Mont Joie, below Contamines (see the map), since blocks of the same nature, with its moraines, may be traced down to St Gervais and Sallenches.

6. Glacier de Miage (de Faucigny), so termed to distinguish it from the Piedmontese Glacier de Miage, with one branch of which it appears to unite on the western ridge of Mont Blanc. It is rumoured that a passage is practicable between these glaciers. Judging from the appearances on the south side, the practicability at present is more than doubtful.

7. Glacier de la Fraisse.

8. Glacier de Trélatête.

9. Anonymous Glacier, descending behind the Aiguille du Glacier, towards Mont Jovet. By this glacier it is probable that the chain may be crossed to the Hameau du Glacier, on the south side.

The first four of the above glaciers belong to the Valley of Chamouni; the next six to the Val de Mont Joie.

10. Le Glacier, anonymous, an immense and splendid glacier, which descends into the Valley of Motet, and gives its name to the Aiguille (du Glacier), whose southern steep it clothes, and to the Châlets (du Glacier), at the foot of the Col de la Seigne. The stream arising from it traverses the Valley of Bonneval, and becomes a considerable tributary of the Isère. Next, in the Allée Blanche,

11. Glacier de la Seigne.

12. Glacier de l'Allée Blanche, has formerly protruded its moraine into the valley, and dammed up the river, forming a lake. This is now dry, and the barrier partly burst. The glacier has retreated.

13. Glacier de Mont Suc, or Aiguille Rouge.

14. Glacier de Miage, already described. Its moraine is perhaps the largest (due to actual glaciers) in the Alps. It fills a wide valley to the distance of four miles, and by its obstruction has formed the Lac de Combal, pushing the river into a narrow channel.

15. Glacier de Broglia.

16. Glacier de Fiêne.

17. Glacier de la Brenva, near Courmayeur, one of the most accessible and most beautiful in the Alps. It descends from a ravine immediately to the east of the summit of Mont Blanc. For continuity and elevation it may be compared to the Glacier de Bossons, but the result is finer; the glacier spans the valley, rising against the foot of the Mont Chetif on the side opposite to Mont Blanc. The river works its way completely beneath the ice. In one particular this glacier is peculiarly interesting, namely, for the astonishing variations of magnitude which it has undergone in the course of a few years. In the time of De Saussure there is every reason to believe that the glacier did not reach down to the River Doire; and it is so represented in Raymond's map, and in every one, including Keller's, down to the time of publication of my Travels in 1842; which shows how little maps can be depended on for the establishment of physical facts as they existed at the date of their construction. In 1818, it had not only passed the river, but raised itself to so enormous a height as to cover and destroy the path which led, and still leads, at a height of several hundred feet (the exact height I regret not to be able to state) above the bed of the Doire, and that with so irresistible a force, as to shatter even the limestone rock of the hill, and to ruin a chapel which was built on that rock.[1]

18. Glacier de Mont Frety.

19. Glacier d'Entrèves.

These two small and steep glaciers are divided by the Mont Frety, a narrow ridge which leads to the Col du Géant. The Glacier d'Entrèves, communicates with the Col du Géant, and by it with the Glacier du Géant on the north side of the chain.

Next, in Piedmontese Val Ferret:—

20. Glacier de Rochefort, descends from behind Mont Mallet.

21. Glacier de la Grande Jorasse from behind the Grande Jorasse, called also Glacier du Pont.

22. Glacier de Triolet descends from a peak near the head of the Glacier de Lechaud, called in *patois* Durotias, or Montagne des Eboulements. This glacier occasioned one of those fearful accidents of which several are on record in the Alps. The motion of the ice becoming accelerated, a large part of the glacier detached itself from its bed, invaded the valley beneath, completely overwhelming the châlets of Pré de Bar, which were exactly in front of it, destroying the inmates and the cattle. This happened in the night of the 15–16th August, 1728.

23. An anonymous glacier, beyond the Glacier of Triolet, descends probably from the Mont Dolent.

The following belong to the Swiss Val Ferret:—[2]

24. Glacier de Mont Dolent.

25. Glacier de la Neva—opposite to the Glacier du Tour, in the Valley of Chamouni A passage across the chain has been effected by means of these glaciers.

26. Glacier du Mont Derré.

27. Glacier de Planereusa.

28. Glacier de l'Arpetta, d'Orsières.[3]

29. Glacier d'Orny. Descends from the Aiguille of the same name.

30. Glacier de l'Arpetta de Champé.

31. Glacier de Dranaz.

The following are on the north face between Martigny and Chamouni:—

32. Glacier de Trient. Descends from the Aiguille of that name, and descends pretty deep into the confined Valley of Trient. In its lower region it is easily traversed.

33. Glacier du Tour. Terminates near the hamlet of that name. The lower part is very steep, but the higher part comparatively even. It is separated from the Glacier of Trient by the Aiguille de Trient, and from the Glacier of Argentière, by the Aiguilles of Argentière and Chardonnet; and between these two Aiguilles there is an icy communication which appeared to me to be practicable. A somewhat difficult passage, of great elevation (11,300 English feet), leads from the Glacier du Tour into the Swiss Val Ferret.

34. Glacier d'Argentière. One of great extent and elevation. Like the Glacier de Miage, it is almost a *simple* one, or nearly straight canal, with no prominent sub-division or very important tributary. A considerable part of it is above the level of perpetual snow. From its extent and elevation it is difficult to explore, and seldom visited. It is separated from the Mer de Glace by the vast pyramid of the Aiguille Verte, and the upper part adjoins the Glacier of Talèfre, being separated only by a narrow though most precipitous chain of Aiguilles.

Thus we have enumerated no less than thirty-four considerable glaciers which bound the snowy region of the chain of Mont Blanc. Estimating at ninety-five square miles the surface of ice and snow belonging to it, each glacier will have on an average nearly three square miles of surface, including the share of *névé* contributing to its formation.

One word remains to be said of the map here presented to the reader. It was originally intended to adopt Raymond's map of Mont Blanc implicitly, with the exception of the Basin of the Mer de Glace, surveyed and mapped by me, which was to be incorporated into the other. But this combination, as might have been foreseen, produced an incongruous whole, and whilst trusting as far as possible to Raymond for the positions of the rivers and principal summits, it was found necessary to adopt material changes in the configuration of the chains, and especially in the positions and forms of the glaciers, for which I adopted all the assistance which my own notes and sketches, as well as published views and descriptions afforded. It was found absolutely necessary to increase the distance between Courmayeur and Chamouni, as given by Raymond, not only on the authority of my own survey, but from the few but valuable data of positions and distances furnished by De Saussure's memorable sojourn on the Col du Géant.[4] These, in fact, have been most relied on for connecting my map with Raymond's, together with the indication of the cardinal points. The result of much labour and adjustment is, after all, in some degree conjectural, and cannot be considered as entirely satisfactory. Still, I have reason to believe that the map is a much more faithful representation of the district than any yet published. Very many names have been added, chiefly on the authority of De Saussure, and from my own inquiries.

2. MAP OF PART OF THE BERNESE OBERLAND. Fig. II.

As this map is, in general, a copy of the old map of Weiss, the foundation of all later attempts to represent with increased definiteness, though without increased accuracy, this glacier region, and as the same *general* considerations apply to it as to the former groups, I shall discuss it as briefly as possible. It is confessedly exceedingly imperfect and rude; some names have been added chiefly on the authority of Gottlieb Studer.

The general direction of the chain of Alps which separates the Valley of the Rhone and the Canton of Berne is inclined nearly 10° more to the meridian than that of Mont Blanc; being North 59° East, and South 59° West; but in the part which we have selected for illustration, the line or direction of the chain appears to be lost, owing to the knot or group of remarkable mountains which are formed upon it. The actual boundary of the chain passes through the crooked line, embracing the Breithorn, Jungfrau, Finsteraarhorn, Kästlihorn, and Siedelhorn. And on either side is a lateral group of remarkable elevation and boldness, that of the Aletschhorn on the south, and the Schreckhorn and Wetterhorn jointly on the north side of the chain. These two detached groups are divided from the main chain by glaciers remarkable for their majestic extent, the great Aletsch Glacier in the first case, prolonged by the Glacier of Lötsch; and the Lower Aar Glacier in the second, prolonged by the Lower Grindelwald Glacier. The two vast double ice valleys just named have been traversed, though only of late years; the great distance over which the ice extends, and the considerable elevation to which it reaches, offering a not inconsiderable risk in the varying climate of these latitudes. The brothers Meyer of Aarau were the first persons on record who traversed completely these wilds of the Oberland. The pass of Lötsch has since been crossed by Hugi, and that of the Strahleck (at the head of the Glacier of the Aar) by Hugi, Agassiz, and others.

The whole district in question contains a nearly rectangular space of snow and glacier, nineteen English miles in length, and ten broad, thus covering 190 square miles, or double the area of the snow and ice belonging to the chain of Mont Blanc.

The *Great Aletsch Glacier* is bounded on all sides by stupendous mountains, and its basin presents an area of no less than thirty-two English square miles. Its *névé* descends from three sides of the Aletsch, one of the boldest and most isolated summit in the Alps, which is believed, on the competent authority of M. Gottlieb Studer,[5] to be at least as high as the Jungfrau. This last mountain, which proudly commands the Valley of Lauterbrunnen and the Col of the Wengern Alp, and is on that side perfectly inaccessible, presents vast snowy accumulations on the side of the Aletsch Glacier, by which it is understood to have been ascended by the brothers Meyer in 1812; but some doubt rests on this achievement, which was first publicly witnessed on occasion of the ascent of Baumann and other Grindelwald peasants in 1828, and was repeated by M. Agassiz and the author in 1841, and more recently by Mr G. Studer. The elevation is 13,716 feet; but the still higher summit of the Finsteraarhorn (14,100 feet), whose snows fall into the Glacier of Vièsch on the one side, and the Lower Aar on the other, was attained first by Leuthold and Währen. two peasants of Hasli;[6] afterwards (in 1842) by a gentleman of Basle, M. Sulzer. No view of its kind in the Alps is more admirable than that from the central part of the higher Glacier of Aletsch, where, as it were, four ways meet, and the united ice-streams from three of them form the vast flat *Eismeer*, whose inclination is only three degrees. One other peculiarity of the glacier must not be passed over. In a *bight* or bay formed by a sudden turn in its direction, and whose opening is closed by the mass of the glacier, there is a considerable lake formed every summer, called the Mörill-see, at an absolute height of 7,600 feet,[7] which presents the singular spectacle of an ice cliff, whose broken fragments float in the green water just like the icebergs of the polar regions. A faithful representation is given in Agassiz' Atlas, plate xii. The Glacier of Aletsch terminates at its lower extremity in an extraordinary manner in a very deep narrow ravine, so deep and so inaccessible that it has been seen, undoubtedly, by very few persons. The principal tributaries of the Aletsch Glacier are—1*st*, From the head of the Lötschthal; 2*d*, From the base of the Jungfrau and Mönch; 3*d*, From the Vièscherhörner; 4*th*, From the *Mittel Aletsch* Glacier, which descends from the Aletschhorn. Another fine glacier, the *Ober Aletsch* or *Jäger* Glacier, expires before it reaches the now low level of the principal body of ice. The length of the glacier, from the last ascent of the Jungfrau to its terminations, may be taken at fourteen English miles, and its mean breadth at one mile and a quarter.

The Glacier of the Lower Aar, first surveyed by Hugi, who took up his residence on it for some time, and since repeatedly visited, and annually inhabited for a few weeks, by M. Agassiz and his friends, presents a noble expanse; and where it is divided by the promontory called the Abschwung into the two branches of the Lauter and Finster Aar, presents a scene of grandeur, and even beauty, which few can rival. I regret that M. Wild's map, long promised in M. Agassiz' new publication, has never yet appeared, otherwise I should have introduced it into the plate which illustrates this paper. I regret this exceedingly, both on account of its importance and the beauty of the execution (which I have seen in the original drawing); and it would not be desirable to replace it by M. Hugi's, or any comparatively imperfect substitute. I must refer to M. Agassiz' writings, and those of M. Hugi, for a description of all that is connected with this glacier.

We will now briefly enumerate the circumferential glaciers which belong to the snowy group we have undertaken to illustrate, extending from the Tschingel-grat, at the head of Lauterbrunnen, crossed by Hugi, to the Valley of Hasli, which, at the Grimsel, completely divides this region of perpetual snow from that of the Gallenstock and St Gothard. We shall commence with the glaciers belonging to the Jungfrau, on the side of Lauterbrunnen, as a well known point.

In the Valley of Lauterbrunnen:—

1. Eiger Glacier.

2. Kühlauinen Glacier.

3. Blumlis-Alp Glacier, descends from Silberhorn (Hugi).

4. Roththal Glacier. By this all Hugi's unsuccessful attempts to ascend the Jungfrau were made.

5. Stufstein Glacier—descends from Ebene Fluh and Mittaghorn.

6. Schmadri Glacier, from Grosshorn and Breithorn.

7. Tschingel Glacier, from Tschingelhorn, affords a not difficult passage into the Kanderthal, and between the Breit, and Tschingelhorn, to Kippel in the Lötschthal.

Towards the Vallais:—

8. Lötsch Glacier. A passage is understood to be practicable to the Ober Aletsch Glacier.

9. The Ober Aletsch Glacier.

10. Great Aletsch Glacier, already described.

11. Vièsch Glacier.

12. Wallibach Glacier, from Kästlihorn.

13. Munsterthal Glacier, from the Löffelhorn

14. Ober-Aar Glacier.

15. Unter-Aar Glacier.

16. Bächli Glacier.

17. Steinlauinen Glacier.

18. Alpli Glacier.

19. Gruben Glacier.

20. Gauli Glacier, descends into the romantic Urbachthal. It may be used to pass over to the Lower Aar Glacier.

21. Hängend Glacier.

22. Grunbergli Glacier.

23. Rosenlaui Glacier.

24. Upper Grindelwald Glacier.

25. Lower Grindelwald Glacier leads to the difficult pass of the Strahleck, on the one hand, and by the back of the Eiger to the Aletsch Glacier, on the other.

Since this article was originally prepared, enterprising travellers have pursued the investigation of the Alpine Glaciers. M. Agassiz has published further researches on the Glacier of the Aar; and the brothers Schlagintweit have made a special study of the principal glacier of the great Glockner in Carinthia, upon the plan of the author's researches at Chamouni. The results are contained in an interesting volume, fully illustrated, entitled "Untersuchungen über die physicalische Geographie der Alpen," which also contains some ingenious observations on other departments of science.

VI. CLASSIFICATION OF GLACIERS.

Glaciers may be classified according to their external forms, which are determined mainly by the figure of the surfaces on which they rest.

1. *Canal-shaped*, of which an example is found in the Glacier de Miage (fig. vii.), which has scarcely any branches, and in the Mer de Glace of Chamouni (fig. iii.), which has two principal tributaries. The Glaciers of Miage, and Aletsch, of the Upper and Lower Aar, the Lower Glacier of Grindelwald, the Glacier of Zermatt, and especially the very striking Glacier of Vièsch in the Vallais (see Agassiz' Atlas, plate x.), are examples of this description of glacier.

2. *The oval-shaped Glacier.* Of this, the Glacier of the Rhone may be taken as a type, or that of Allalein in the Valley of Saas (fig. viii.), which produces a lake in the same way as that of Combal in the Allée Blanche. Of this kind are the Glaciers of La Brenva, and the Upper Glacier of Grindelwald.

3. *The basin-shaped Glacier* is contained in a cavity of the mountains of an oval form, so that the breadth of the outlet is not a large fraction of the diameter of the glacier itself. Fig. ix. shows a ground-plan of the Glacier of Talèfre (a tributary of the Mer de Glace), the outlet of which has but one-seventh of its greater diameter.

4. *Glaciers of the Second order.* These are exceedingly numerous, and denote the small glaciers which are found niched in the rocks of the higher Alps, without any connection with the great glaciers which descend below the level of the snow line. The smallness of these glaciers (which probably appear and disappear, in some cases, from time to time) is owing to the smallness of the area of snow whence they draw their nutriment. They therefore die away at a short distance from their origin. The name of Glaciers of the second order was given by De Saussure, and was intended to include those which occupy *cols* or mountain passes, such as the Col du Géant, the Col du St Theodule, the Col of the Griès. Other glaciers of this kind are almost numberless in the Alps. An idea of their appearance may be had from plate ix. of my work on the Alps of Savoy, and fig. 4 in this map, which is a plan of one near the Simplon.

VII. SLOPE AND CONTOUR OF GLACIERS.

The slope of glaciers is very variable, commonly greater in the highest and lowest parts of their course, and least in the middle. Fig. v. shows the mean slope of different portions of the Mer de Glace. The *surface* of the glacier below the snow line is *convex* (see the sections in fig. iii.); above the snow line (in the *névé*), concave. This was supposed to be due to the reflected heat, from the ground melting the lateral parts, but it appears to be owing to a far more general cause.

VIII. RATE AND CAUSE OF MOTION OF GLACIERS.

This part of the subject being one properly of pure physics, not immediately connected with physical geography, cannot receive anything like a full treatment within the limits prescribed to us. It may, however, be stated that the rate of motion of a glacier from day to day and month to month was first correctly ascertained by the author's observations on the Mer de Glace in 1842. Notwithstanding the interest which the subject had excited, and the ample means employed by different naturalists for investigating it, the value of a correct determination of this fundamental fact was unperceived, and no adequate means taken for fixing it. The annual motion generally admitted a few years ago, on the respectable authority of Ebel, was fourteen feet a-year at Chamouni, and twenty-five feet at Grindelwald; and this result was said to have been obtained by sticking fir trees into the crevices, and watching their motion. Had the experiment been correctly performed, the fourteen feet just mentioned would have been found to be moved over from five to ten days (according to the position), instead of in 365! It is curious to find a competent physical writer like Raymond accepting these results, and then exclaiming: "Cette vitesse (quatorze pieds) est enorme!" Even in the most recent times, the Swiss naturalists, Hugi and Agassiz, differed in the proportion of three to one in the annual motion assigned to one and the same glacier—that of the Aar—and the latest experiments prove the error to have lain with the most recent observer. The general results of the author's observations, now sufficiently confirmed from other observations, are these:—

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[1] See the attestation of these singular facts in my Travels, pp. 205, 206, and in Captain Hall's Patchwork, i., 108.

[2] For the correct enumeration of these, I am indebted to a kind communication of M. de Charpentier.

[3] Or Glacier de Portalet.

[4] Voyages, § 2036.

[5] Topographische Mittheilungen aus dem Alpengebirge, 1843.

[6] Hugi Alpenreise, 1832, p. 206.

[7] Aletsch hütte, 7181 French feet.—*Hugi.*

(1.) That the motion of the Mer de Glace during summer and autumn is as great as four feet in twenty-four hours in some places, and only eight or nine inches in others.

(2.) This motion is rigorously *continuous*, and not by fits and starts.

(3.) The velocity (*cœteris paribus*) increases with the slope.

(4.) The velocity is in direct proportion to the heat and moisture of the weather jointly.

(5.) That the velocity, though diminished (according to this rule) in winter, is never null, or nearly so.

(6.) The centre of the glacier moves faster *in every case* than the sides (contrary to the formerly received opinion). It is inferred that the top moves faster than the bottom.

(7.) The variation of velocity from point to point is greatest near the side. In the centre it is sensibly uniform.

(8.) The change of velocity at different points of the breadth of the glacier takes place in a perfectly graduated manner, by the yielding of the entire mass, not *per saltum*, nor by the justling of detached fragments, nor by the formation of open rents.

These eight *facts of motion* demonstrated in "Travels in the Alps of Savoy" appear to be only consistent with the theory founded upon them, namely, that the glacier slides over its bed in the same manner as a cohering semi-fluid would do; the semi-fluidity being necessary to commence the motion, where the contracting form of the valley or irregularity of the bounding edges could not possibly permit the escape of the mass of the glacier considered as a solid body. The Glacier of Talèfre, for instance (fig. ix.), presents a single narrow opening, by which the annual overcharge of the vast basin is delivered as from a waste-pipe. Motion would evidently be impossible in such a case, except by an approximation to fluidity.

The semi-fluid (or semi-solid) hypothesis satisfies all the above conditions of observations; for

(1.) On the small inclinations of many glaciers, and with the enormous friction to which the motion of the mass is exposed, if its parts did not yield over one another, motion could not be commenced at all.

(2.) Fluid motion, by its very mode of generation, and by the minuteness of the sphere of cohesive action, is *continuous*.

(3.) The velocity increases as the slope.

(4.) Any cause increasing the liquidity of a semi-solid, or the effective hydrostatic pressure, will increase the rate of its flow. Such a cause is the infiltration of all the pores of the ice of a glacier by water during sunshine or mild rain.

(5.) By the laws of penetration of heat and cold into great masses, it is certain that the depths of the glacier cannot be entirely frozen even in winter.

(6.) Owing to friction, all fluids moving in channels move fastest at the centre and at the surface.

(7.) The variation of velocity in viscous fluids (such as rivers) is always greatest near the sides and bottom, and least at the centre and surface.

(8.) Owing to the smallness of the sphere of action and the mobility of the parts, no positive discontinuity of any extent can be produced in viscous bodies—they change the mutual position of their molecules in a manner sensibly *continuous*.

Other and important arguments for this theory may be drawn from the remarkable ribboned or veined structure of the ice, to which the author drew especial attention for the first time in 1841, and of which an explanation was given conformably to the VISCOUS OR PLASTIC THEORY of glacier motion in 1842. But our limits positively forbid our entering on this more extended and difficult inquiry.[1]

IX. ON THE FORMER EXTENT OF GLACIERS, AND VARIATIONS OF THEIR SIZE.

1. *In Historic Times.*—Glaciers vary in size, surface, depth, and protrusion into the valleys, from one year to another, and notably during periods of ten or twenty years.[2] Some glaciers increase at the very same time that others not very distant from them diminish. These variations are difficult to explain satisfactorily. If we go back some centuries, these variations are more striking and more general. There is full reason to believe that in the fifteenth and sixteenth centuries many passes of the Alps, now exceedingly difficult and dangerous, were comparatively easy and frequented. This is established, not only by oral tradition (which is sufficiently plain), but by documentary evidence, to which we cannot here refer more minutely. Passes of this description were, for example—(1.) That by the Great Aletsch and Grindelwald Glaciers from Brieg to Grindelwald; (2.) from Saas to Anzasca by Monte Moro; (3.) from Zermat to Evolena by the Col d'Erin; (4.) from Bagnes to Aoste by Chermontane; (5.) from Chamouni to Courmayeur by the Col du Géant. On this subject I must refer to M. Venetz' excellent paper in the first volume of the Transactions of the Swiss Naturalists, and to the abstract of it in Agassiz' *Etudes sur les Glaciers*, chap. xvi.

2. *In Remote or Geological Epochs.*—The immediate neighbourhood ot most of the glaciers of the Alps afford unequivocal traces of their having been much more extended at periods anterior to history than even in the present day, although we have seen that for some centuries they have been on the increase. Vast moraines, or heaps of transported blocks and gravel at considerable distances (a mile or more) in advance of the present bounds of the ice, have been admitted on all hands, at least since the time of De Saussure, to attest this fact. Those most frequently quoted are the old moraine af Lavanchi near Chamouni, belonging to the Glacier des Bois; the moraine of the Glacier of Rossboden, on the Simplon; and that of the Glacier of the Rhone. Admitting these (and almost every Alpine valley affords similar evidence) as a sufficient proof, up to this point, of the former greater extension of glaciers, we find it impossible to draw a line between them and other moraines, in or near the mouth of valleys whose heads are still occupied by glaciers; and this evidence is strengthened, if we observe the same character of the rocky surfaces which the friction of glaciers undoubtedly produces, namely, perfectly smooth rounded dome-like forms[3] (called *roches moutonnées* by De Saussure), grooves, and striæ in the direction in which the ice must have moved; and in some cases a fine, even-polished surface, such as is produced by continued attrition, but never by crystallization. Such are the phenomena seen near St Gervais, in Savoy, where (as already mentioned) the travelled granite blocks and gravel of Mont Blanc may be continuously traced from the neighbourhood of Sallenches (and probably much farther) up to the existing moraines of the Glacier of Bionassay, and others in the same direction. Such, too, is the great moraine near Kandersteg, which must have been formed by the glaciers of the valleys of Gasteren and Oeschinen—that in the Swiss Val Ferret, formed by the Glacier of Salena. Such, too, are the polished rocks at Saas and at the Handeck (in Hasli), due to the anciently extended glaciers of the Montagne de Fée and of the Upper and Lower Aar. But so much being admitted, it seems impossible to stop short here. The continuity of moraines and of the effects of attrition seems to connect the vast deposits of the blocks of Monthey in the Valley of the Rhone below St Maurice with the undoubted glacier deposits of the Valleys of Trient and Ferret; and the blocks of Monthey cannot reasonably have any origin ascribed to them, which must not be extended by precise parallelism of circumstances to the innumerable forests of primitive boulders which once strewed the whole plain of Lower Switzerland, and which, reaching the Jura Mountains (formed entirely of limestone), has left an imposing memorial of its existence, in the vast belt of granitic masses, but slightly worn or rounded, which lie along the face of that chain facing the Alps, at a height of 800 feet above the Plain of Switzerland and the Lake of Neufchatel.[4]

Startling and improbable as such an origin must be admitted to be at first sight, it is found, upon examination, that every other hypothesis yet proposed to explain so important and striking a geological phenomenon is pressed with not less formidable difficulties. The reader who would see this question discussed in a manner which can alone render him competent to come to a just conclusion on the subject, must consult the original paper of Venetz already quoted, but more particularly the masterly essay of M. J. de Charpentier on the Erratic Phenomenon, being the second part of his *Essai Sur les Glaciers.* From this last named work we have borrowed a map (fig. iv.), showing (with as much accuracy as was known at the time, subject, however, to considerable modifications in detail) the boundary of the *Ancient Glacier of the Valley of the Rhone*, comprising its numerous tributaries, as indicated by the *extreme* limits of distribution of angular blocks which have been *mineralogically identified* with those found *in situ* in the chain of valleys which *debouche* into the Rhone valley.[5] To M. Escher de la Linth we are indebted for a map of the distribution of the Erratics of Switzerland. The Valleys of the Arve, Aar, Reuss, Linth and Rhine, have each given origin to an outspread of blocks over the plains of Switzerland and the opposing mountains, similar to what is here indicated for the Valley of the Rhone.

The formerly greater extension of glaciers is now (1853) very generally conceded as demonstrated in other countries besides the Alps. The phenomena are strikingly identical in those where glaciers still abound, as in the mountains of Himalaya and in those of Norway. In both of these widely distant regions unquestionable moraines may be seen extending far beyond the termination of existing glaciers.

EXPLANATION OF THE FIGURES.

Figure I. is a map of the chain of Mont Blanc, extending from the neighbourhood of the Col de Bonhomme to the Col Ferret. The basis is Raymond's map; but nearly all the eastern part is taken from Professor Forbes' survey of the Mer de Glace and its tributaries. The object of it is to show the origin and termination of the different glaciers. For this purpose the more palpable oversights of Raymond's map have been in some measure corrected, but much is still confessedly imperfect.

Figure II. is an outline of the principal glaciers of the Bernese Oberland, chiefly taken from the old map of Weiss. Some additions and corrections have been made; but, at the best, it is a rude and imperfect representation of the natural features, even in the more accessible parts, such as the neighbourhood of Grindelwald, but no better exists at present, nor is likely to do so before the still remote completion of the Swiss Government survey.

Figure III. is a reduction, in outline, of part of Professor Forbes' map of the Mer de Glace of Chamouni. It is intended to illustrate, 1*st*, The general form of the more accessible part of that glacier, and the position of its moraines; 2*d*, The exact form and distribution of those remarkable lines on its surface called the *Dirt Bands*, which are more accurately laid down than they have hitherto been; 3*d*, Profiles of the glacier, as seen in section, are introduced at different points of its length; 4*th*, The approximate annual motion of the ice, at different points referred to by letters, is shown to the eye by arrows of various lengths; the numbers alongside of which give the annual progress in English feet; of these, the points C, P, S, and T, are the best determined. The slope of this glacier is shown in figure V.

Figure IV. is taken principally from M. de Charpentier's *Essai sur les Glaciers*, and shows the approximate distribution over the surface of Switzerland of erratic blocks which had their origin in the Valley of the Rhone. The tinted part, which includes the boundaries of this erratic deposit, indicates, according to Charpentier, the space once covered by the Glacier of the Rhone. Some corrections have been introduced from the later map of M. Escher de la Linth. The extreme height of the erratic formation, at different points, is marked in the plate on the authority of De Charpentier, and Elie de Beaumont.

Figure V., already referred to, shows the actual mean slope of the Mer de Glace of Chamouni, for different portions of its length.

Figure VI. is a graphic representation of the height of the snow line in different latitudes, and in both hemispheres. It is chiefly founded on the authorities cited by Humboldt in the third volume of his "Asie Centrale." It is sufficiently evident that a curve drawn through the points where perpetual snow commences, does not tend to reach the level of the sea in the Northern Hemisphere, though it does in the Southern.

Figures VII., VIII., IX., X., represent the four classes into which glaciers may be divided. Figure VII. is a sketch du Glacier de Miage, representing the class of *canal-shaped* glaciers or those having tolerably uniform breadth, and few tributaries. Figure VIII. gives an idea of an oval glacier, illustrated by that of Allalein Glacier in the Valley of Saas. Figure IX., or the *basin-shaped* glacier, is a reduction of Professor Forbes' map of the Glacier de Talèfre. Figure X. is a sketch of a glacier of the second order of De Saussure, illustrated by the small and elevated Glacier of the Schönhorn behind the Simplon Hospice.

[1] See Travels, &c., chap. viii. and xxi.

[2] See a remarkable example above referred to in the Glacier of La Brenva.

[3] See Agassiz' Atlas, plates viii. and xv.

[4] The vignette of fig. iv. represents the *Pierre à Dzo*, one of the blocks of Monthey. The *Pierre à Bot*, 800 feet above the Lake of Neufchatel, is formed of granite (*protogine*) of the chain of Mont Blanc, which is distant, *in a right line*, seventy-five English miles. The dimensions of this stupendous stone are, according to Von Buch, 50 × 20 × 40 French feet, containing, therefore, 40,000 cubic feet.

[5] See further on this subject, Playfair's Illustrations of the Huttonian Theory, art. 349, and Works, vol. i., 29. Agassiz' Etudes sur les Glaciers, chap. xviii. Edinburgh Review for April 1842. Travels in the Alps of Savoy, &c., chap. iii. I cannot help adding, now that the existence of ancient glaciers has been so prominently brought forward as an explanation of geological phenomena in our own country, that I find that my excellent and learned friend, Professor Jameson, was in the habit of stating in his lectures the possibility of such a geological cause. This is established by notes taken by myself when I had the advantage of being a student in his class in 1827.

PLATE 10

THE PHENOMENA OF VOLCANIC ACTION,

AS EXEMPLIFIED IN

THE REGIONS VISITED BY EARTHQUAKES,

AND

THE DISTRIBUTION OF VOLCANOES OVER THE GLOBE.

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I. OUTLINES OF VOLCANIC PHENOMENA.

a. THE PHENOMENA OF EARTHQUAKES.

THE object of the annexed map is to represent graphically, according to geographical distribution and extension, the influence which the reaction of the interior fires of our planet exercises on its crust and surface, as exemplified in the regions of earthquakes, and the distribution of volcanoes over the globe. Before entering on the geographical explanations, however, it may be useful, shortly, to inquire into the nature and extent of volcanic action. In the following sketch, in which the subject will be examined rather in a physical than a geognostical point of view, we shall be guided chiefly by the comprehensive and luminous representations of Alexander von Humboldt.

Earthquakes and volcanoes, which stand in intimate connection with one another—the former being, to some extent, the result of the latter—are to be considered as the remains of great geognostical revolutions of our globe, previous to historical times, rarely changing the place of their appearance, and becoming active at intervals of time varying from an hour to a hundred years. We shall treat of them according to the above mentioned relations, and in their transition from a purely dynamic concussion, as evinced in the upheaving of entire continents and mountain masses, to the production and effusion of thermal springs, the escape of gaseous and sulphureous vapours, the eruptions of mud, and the more awful phenomena of burning mountains. The germ of all these phenomena—the origin of moving power—is to be sought for in the depths of the earth, in its temperature increasing with distance from the surface. But at what depth a lava-producing heat may be found is a question towards the elucidation of which modern research has only supplied materials for an uncertain approximation.[2]

The *Concussions of Earthquakes* consist in more or less violent commotions of particular parts of the surface of the globe. These are often so slight as only to be perceived by those accustomed to the phenomena, in which case there remains no visible mark of their activity. Sometimes, however, they produce violent convulsions of the earth, which, in their destructive effects, transmit lasting memorials to future generations. These concussions are of a threefold character; they are distinguished by a series of *perpendicular*, *horizontal*, or *undulatory* and *rotatory* motions, which follow each other in rapid succession.[3] The perpendicular mine-like explosion, acting from below upwards, was exhibited in the most striking manner during the destruction of Riobamba in 1797, when the bodies of many of the inhabitants were thrown upon a hill several hundred feet high. The horizontal vibration acts apparently in an undulating manner, causing an alternate rising and sinking of the earth in the direction of its course. Rotatory or circular concussions are the most rare, but most destructive of all, often following several cross directions, and causing a whirling movement of the earth, by which buildings, without being overturned, are twisted, parallel rows of trees are deflected, and fields, covered with different kinds of grain, are made to change their positions. This last movement, which is only observed to occur in the greatest earthquakes, was conspicuous in those of Lisbon and Calabria, the regions of which are represented on the map. Dolomieu, who gives a detailed account of the latter, says,[4] that the best idea of this undulating and springing motion may be obtained by placing small cubes of moist clay and sand near each other on a table, and communicating to them a vertical stroke from below, and at the same time moving the table horizontally from side to side.

The Progression of Earthquakes occurs most frequently in a linear direction, undulating with a velocity of from twenty to thirty geographical miles in a minute; sometimes it is in concussion circles or great ellipses, in which, as from a centre, the vibrations extend with decreasing force towards the circumference. One of the finest examples of linear progression was afforded by the great earthquake of Guadeloupe in 1843, which, within a space of from sixty to seventy miles in breadth, was observed over an extent of three thousand miles in length. The second kind of motion was exemplified in the great earthquake of Calabria in 1783, when the small town of Oppido formed the centre of a circle round which, within a radius of twenty-two miles, all the towns and villages were overthrown and destroyed.

The Duration of Earthquakes is, in proportion to the effects which they produce, exceedingly short; and it appears almost as if the amount of the one stood in inverse ratio to the other. The most destructive shocks are generally over in a moment. During the great earthquake of Caraccas, by which ten thousand lives were sacrificed, and a flourishing province was reduced to ruins, three terrific shocks, each of which lasted from three to four seconds, followed each other within the space of fifty seconds; and the great earthquake of Lisbon, during which sixty thousand persons perished, lasted only about six minutes. The horror of these frightful visitations is greatly increased when they happen suddenly, without any warning of their approach; usually, however, great shocks are preceded by slighter vibrations of the earth, and by subterranean detonations.

These *Detonations*, which generally accompany an earthquake, but which do not increase in proportion to the strength of the vibrations, have been compared to the roll of thunder, the rattling of heavy waggons over a stone pavement, to the discharge of cannon at irregular intervals, or the hollow sound of an exploding mine. This noise is sometimes heard as distinctly at a great distance from the scene of an eruption as in its immediate vicinity, and, as has been well ascertained, at precisely the same moment of time. Hence it is inferred that the sound could not have been propagated through the air, since in that medium observation shows that a certain portion of time is required to transmit it from one station to another. Solid bodies are the best conductors of sound, which is transmitted through baked clay with a velocity ten or twelve times greater than through the open air. But as the known laws of acoustics are insufficient to account for this phenomenon, it is conjectured that the sounds must have originated in the interior of the earth at a nearly equal distance below the surface at all the places where they were observed. In Caraccas, in the grassy plains of Calabozo, and on the banks of the Rio Apure, there was heard, on the 30th April 1812, without any appearance of an earthquake, a sound resembling a loud peal of thunder, at the moment when, at the distance of seven hundred miles to the north-eastward, the volcano of St Vincent discharged from its crater an immense stream of lava. It is remarkable that these sounds are often heard during a considerable period of time, without any earthquake taking place; for example, in the Dalmatian Island, Meleda (twenty miles from Ragusa), such detonations occurred from March 1822 till September 1834, almost without any movement of the earth; while, on the other hand, Humboldt has shown that the great shock in the earthquake of Riobamba (4th February 1797)—one of the most frightful phenomena in the physical annals of our globe—was not accompanied by any noise whatever. But the most remarkable instance of uninterrupted subterranean noise, without any appearance of an earthquake, is the occurrence of the phenomenon which is known in the highlands of Mexico under the name of the bellowings and underground thunders (bramidos y truenos subterraneos) of Guanaxuato. Under this celebrated and rich mining town, which is situated far from any active volcano, the sounds continued for a month, and neither on the surface of the earth, nor in the mines, sixteen hundred feet deep, was there the slightest appearance of an earthquake.

It is one of the undoubted characteristics which the phenomena of earthquakes call forth, that while they have their seat deep in the interior of continents, they also communicate, in the most remarkable manner with the sea. Wherever great earthquakes occur on coast-lands they are accompanied by violent agitations of the adjoining sea. During the earthquake of Lisbon, the sea rose to a height of fifty feet above its ordinary level. In the open ocean, the effect upon a ship resembles that produced by striking upon a rock under water. The effects of earthquakes on the waters of a continent are manifested in the rising and falling of lakes, the interruption of springs, &c.

Although an earthquake appears, at first sight, to be only a dynamic motion connected with space, yet we know, from the most positive experience, that it not only has the power to raise vast tracts of land above their former level (as, for example, Ullah-Bund, after the earthquake of Cutch: and the coast of Chile, to an extent of one hundred thousand square miles), but also that during the concussion, hot water, steam, mephitic gas, mud, black smoke, and even flames, have been discharged. A. von Humboldt[5] has touchingly described the impressive, and entirely peculiar effect which the experience of an earthquake, for the first time, produces upon the observer: "From early childhood," he says, "we are accustomed to contrast the mobile element of water with the immobility of the soil on which we stand. All the evidences of our senses have tended to confirm our belief in this contrast; but when suddenly the soil begins to heave, the sense of some unknown mysterious natural power, acting upon and moving the solid globe, seizes upon the mind, and in a moment the illusion of the whole of our earlier life is annihilated."

That the great phenomenon of the slow, imperceptible *raising* and *sinking* of whole continents (as exemplified especially in Scandinavia and Greenland), which in recent times has attracted the attention of the entire geological world, does not come under the category of that partial upheaving of countries, caused by the more concentrated shocks of earthquakes, is evident. We only know that the active cause is subterranean, and therefore the extent of these phenomena could not, with propriety, be omitted in a map which treats of the geographical distribution of the effects of subterranean forces. We shall therefore recur to the subject afterwards.

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[1] A. von Humboldt's "Kosmos," German edition, band i., s. 208-257.

[2] The phenomena of volcanoes and hot springs led to the belief, prevalent among philosophers since the earliest times, that there exists a central heat in the globe; and the numerous observations made in mines, which, however, only extend to a depth of from 1,000 to 1,500 feet, have confirmed this opinion, although the results of these observations, in consequence of the presence of the miners with their lamps or candles, the explosion of gunpowder, the admixture of external air, and other causes, are not satisfactory. M. Cordier, who collected all these observations previous to 1827, is of opinion that the increase would not be overstated at 1° Cent. for every 25 metres, or about 1° Fahr. for every 45 feet, a result which is supported by the high temperature of water in Artesian wells, since the careful observations in the well of Grenelle, of MM. Arago and Walferdin give an increase of 1° Cent. for every 31 or 32 m[illegible] der and Völkerkunde, ii., s. 773. See also a notice by Mr Taylor, on the temperature of the earth and [illegible] February 24, 1840.

[3] Besides the three above noticed characteristics of [illegible] kind is frequently described as tremulous shocks, termed *trembleres* by the inhabitants of the countries [illegible] re they occur very frequently. These are the least destructive in their effects, and generally last only [illegible] sometimes they continue at intervals for several days together.

[4] Berghaus' Geographischer Almanach, 1837, p. 46. Se[illegible] pp. 1-171, and in that for 1838, pp. 1-188, two valuable treatises on Volcanic Phenomena by an anonym[illegible]

[5] Kosmos, band i., s. 224.

b. THE PHENOMENA OF VOLCANOES.

As earthquakes are often accompanied by eruptions of water and watery vapours, so we recognise in the small mud volcanoes, which are accompanied by the eruption of flames, a transition to the proper volcanoes or burning mountains. These latter, forming a permanent, or at least a frequently renewed communication between the fluid interior of the earth and the atmosphere which surrounds its outer crust, are to be considered as safety-valves for the country in their vicinity; for observation shows that the most destructive earthquakes occur at a distance from active volcanoes, as in Venezuela, Portugal, Greece, and Calabria. In a proper volcano the reaction of the interior upon the surface continues for a very long period of time; it may, as was once the case with Vesuvius, remain uninterrupted for centuries, and then present itself anew with increased activity. The degree of this activity, and especially the frequency of eruptions, appears to stand in such relation to the height of a volcano, that the latter are much more frequent when the cones are of comparatively low elevation. Thus, for example, while the low volcano of Stromboli, in the Lipari Islands (2,957 feet) has continued in a state of constant activity from the earliest ages, serving the purpose of a lighthouse to the navigators of the Tyrrhenic Sea, the gigantic volcanoes of Cotopaxi (18,875 feet) and Tunguragua (16,424 feet) in the Andes of Quito, have only been active once in a hundred years. If the origin of these volcanoes is at an equal depth below the surface, it must require greater power to throw the molten masses to an elevation, in the one case, six or eight times greater than in the other; for this reason the effusion of lava is much less frequent from elevated cones, and among the higher volcanoes of the Quito range, Antisana is perhaps the only one which has emitted lava streams.

These *Lava Streams* break out in irregular intermitting springs of molten earthy matter, preceded by iets of aqueous vapour, acids, and mud. The openings from which all these substances are poured forth are called *craters*, the size and form of which are totally independent of the dimensions of the volcanic mountain.

Volcanic Eruptions are generally preceded by subterranean sounds, and the other phenomena usually attendant on earthquakes; these are succeeded by dense columns of smoke impregnated with a great variety of gaseous substances, which, according to the state of the atmosphere, assume different forms, and are often interspersed with streams of burning sand; then follow molten masses and burning stones, which are vomited forth with fearful noise, and with such enormous force, that on one occasion a piece of rock, measuring three hundred cubic feet, was thrown from the crater of Cotopaxi to a distance of more than eight miles. While these substances are thus expelled from the crater,[1] and indeed even before the eruption commences, the vibrations of the soil usually cease, and the stream of lava, escaping from the lower edge of the crater, emitting a thick streak of greyish smoke, flows down the mountain, sometimes with great rapidity, but more frequently as a slow majestic fiery current.[2]

The eruption of lava, however, is not the last of the phenomena which usually follow each other in regular succession; for, after it has ceased to flow, the activity of the vent continues uninterrupted. The appearance of volcanic ashes is always the sign of the termination of a great eruption; the fine light lava-dust rises in such quantities, that for hours, and even days together, large tracts of country are enveloped in midnight darkness,[3] while the soil is covered with it to a depth of five or six feet; in the case of Herculaneum, indeed, the lava dust, driven by the wind, accumulated to a depth of from seventy to one hundred and twelve feet.

Volcanoes which raise their summits far above the limits of the snow-line present many peculiar appearances; a sudden melting of the snow indicates the approach of an eruption, even before smoke is visible, and this rapid thawing of the accumulated snows occasions destructive floods and rapid torrents, in which heaps of smoking ashes are floated along on thick blocks of ice.

II. GEOGRAPHICAL DISTRIBUTION OF VOLCANIC PHENOMENA.

a. DISTRIBUTION OF EARTHQUAKES.

However formidable in appearance the eruption of a volcano may be, it is always confined to narrow limits; but the case is very different with earthquakes, which although the oscillations they produce are scarcely perceptible to the eye, often extend their ravages over thousands of miles.

In so far as yet known, earthquakes may occur at any point of the earth's surface. No country, whatever the nature of its formation, is entirely exempt from such visitations. Granite and mica-slate are affected by them as well as mountain limestone and sandstone, and trachyte as well as amygdaloidal formations: thus in the loose alluvial soil of Holland, as in the vicinity of Vliessingen (Flushing) and Middleburg, earthquakes have occurred. Even large plains and marshy territories are not exempted from the destructive effects of these phenomena which occur with equal power in all zones and at all seasons. If we could obtain information of the daily condition of the entire surface of the globe, we should probably soon be convinced that that surface is continually agitated by concussions in some of its points, and that it is incessantly subjected to the reaction of the interior masses.

The immense area over which these concussions extend is sometimes almost incredible; of this the great earthquake of Lisbon furnishes the most remarkable example. The concussion assumed the form of an ellipse, in which the longest diameter, characterised by the destruction which was produced on its course, extended over three hundred miles. The diameter of the district of concussion, or the space over which the shock was perceptibly felt, extended to two thousand seven hundred miles; and the area of vibration, or the greatest extent over which water was observed to oscillate at the surface, extended to about four thousand miles.

I. EARTHQUAKES OF THE OLD WORLD.

In our rapid survey of the great earthquake districts represented on the map, for the materials of which we are greatly indebted to the elaborate and valuable work of E. K. A. von Hoff,[4] we shall commence with that of the Mediterranean Sea, which, uniting on the east with the district of Central Asia, extends from the Azores and the Canary Islands to Lake Baikal, and forms, as Humboldt remarks, probably the longest and most regular zone of volcanic action on the surface of the globe—far surpassing in extent the volcanic girdle of the Andes in South America. From the earliest times volcanic appearances have manifested themselves on a line extending from the Caspian Sea to the Azores; this may, therefore, be considered as the centre from which the earthquake proceeds, and as a general rule, observable in this and in all other volcanic districts, the violence and frequency of the shocks decrease with the distance from the central line; and the direction of the primitive mountain-chains determines, in most cases, the course of the earthquakes, especially of such as extend from a central line in a northerly direction. Although it is not possible strictly to define the limits of earthquakes, and the boundaries marked on the map are only to be understood as an approximation to this; yet it may be affirmed that, in the Mediterranean district, the boundaries of the principal concussions are limited by the more or less parallel position of the Pyrenees, the Alps, Carpathian, and Caucasian mountain-chains, in reference to the central line. In the south, they extend probably to the great African Desert, to the Delta of the Nile, and the Desert of Arabia. In order to show the course and extent of the phenomena, we shall give an outline of the progress of one of the greatest and most destructive earthquakes of modern times, which occurred within the limits of the *Mediterranean district*, or which, at least, had its origin there.

Earthquake of Lisbon, 1755.—This earthquake commenced on the 1st November. Suddenly a sound of subterranean thunder was heard; this was immediately succeeded by a violent shock, which demolished the greater part of the city; and in the course of six minutes sixty thousand persons perished. The movement of the earthquake was undulatory; and it is calculated that it travelled at the rate of twenty miles a minute. A space more than four times the extent of Europe, or nearly one-twelfth of the superficial area of the globe, was shaken by this earthquake, which had for the axis of its shock a line extending from Mogadore, on the coast of Marocco, along the west coast of Portugal, to Cork in the south of Ireland. From Lisbon, the central point, the line of devastation extended northwards to Oporto, and southwards to Ayamonte, where the Guadiana falls into the Bay of Cadiz. Within this entire space the sea, fearfully agitated by the concussion of its bed, caused the greatest destruction. At Cadiz a wave sixty feet high rolled over the land; at Lisbon, as already remarked, the sea rose fifty feet above its usual level. At Kinsale, in Ireland, the sea raged into the harbour, and overflowed the market-place; and at Funchal, in Madeira, it rose to fifteen feet above the highest water-mark. The space within which this earthquake was observed on land extended in an elliptical form from the Island of Madeira to Abo in Finland, and from Scotland to Sardinia. In Scotland, the water in Loch Lomond, Loch Katrine, Loch Long, and Loch Ness, was observed to rise and fall repeatedly to an extent of two or three feet; and this movement of the surface of the water was especially observable in the lakes of Germany, Switzerland, and France, as well as in some of those in Scandinavia. The agitation of the waves of the sea extended even to the Antilles, where the islands of Antigua, Barbadoes, Guadeloupe, and Martinique were overflowed; and a ship forty leagues to west of St Vincent suffered so violent a shock that the seamen were thrown from the deck to the height of eighteen inches perpendicular; at the same time an unusual movement was observed on the surface of Lake Ontario in North America.

No part of Europe is more frequently visited by earthquakes than Italy, and the islands in its vicinity. Pompeii and Herculaneum were destroyed by an earthquake (A.D. 63) sixteen years previous to the time when, after having been rebuilt, they were buried under the ashes and lava ejected from Mount Vesuvius. Since that time earthquakes have been frequent in Lower Italy and Sicily; but up to the twelfth century they were less frequent than in later times, especially in the eighteenth and nineteenth centuries.

The great Earthquake of Calabria, February 5, 1783.—As an illustration of phenomena, this earthquake is less remarkable for its extent than for the concentration of its operative effects; for the surface over which the shocks were felt with alarming intensity did not exceed an area of five hundred miles. Within this space about two hundred towns and villages were destroyed; nearly one hundred thousand of the inhabitants perished, and the face of the country was so completely changed that many disputes afterwards arose as to whom the property should belong which had so far shifted its position. The convulsions extended over Calabria ultra, and along the granitic range of the Apennines from north to south, but were not perceived to the eastward of that chain. The central point of this earthquake was the town of Oppido in Calabria ultra. Hamilton says that a circle drawn round this, with a radius of twenty-two geographical miles, would include that district which had suffered most severely from the shock; the concussion was felt northwards of Oppido to Cetraro, a distance of seventy-two miles; and on the west it extended over the Lipari Islands to Patti in Sicily. The limits of this earthquake, as well as the countries in the environs of Etna and Vesuvius which are almost incessantly convulsed by earthquakes, are delineated on the small special map of the volcanic districts of Lower Italy.

The district of the earthquake which visited the *south-eastern part of Europe on the 22d January* 1838 lies far to the eastward of the central line we have been describing. The shock was observed in the vicinity of Vienna and Constantinople, as well as in the southern provinces of Russia, and was very destructive in the countries of the Lower Danube, at Bukarest, &c.

Besides these special earthquake districts, the other parts of Europe belonging to the *Mediterranean district*, especially Greece and Turkey, have been visited by frequent and very violent concussions. This volcanic region extends over Asia Minor, Syria, and Palestine, to the Caspian Sea and the Caucasian Mountains, where the country in the vicinity of Tiflis has suffered severely from shocks of earthquakes both in earlier and later times. Persia and the countries about the Caspian Sea, form the connecting link between the Mediterranean district and the district of Central Asia, in one direction, and the south Asiatic district in another. The countries of Asia have suffered from the effects of earthquakes as great changes of surface as those of Europe, or perhaps even greater, when we take into consideration the earthquake of Cutch, which, in 1819, caused such alterations that the bed of the eastern branch of the Indus, previously only one foot deep, suddenly attained a depth of twenty feet; or the great earthquake in Syria, 20th May 526, which was most severely felt at Antioch, and during which it is said that two hundred and fifty thousand lives were lost; or that which devastated the same country in 1837, extending over a space of five hundred miles in length by ninety in breadth, and by which more than six thousand persons perished.

In the District of Central Asia the course of linear concussion follows, in general, the direction of the great mountain-chains. On the range of Thian-chan the concussions extend, on both sides, from Hami and Turfan over Akou and Bokhara to the great depression of Turkestan. To the northward of the Thian-chan, we must consider the eastern termination of the mountain system of the Altai, the platonic fissure of Lake Baikal, and the warm springs of the Orkhon river, as the central point of that volcanic activity which, among others, caused the destruction of Karakhorum at the end of the thirteenth century. From this point the concussions spread from east to west, and, in later times especially, on the northern declivity of the Sagan Mountains to the west end of the Kolyvan Altai. They were felt in the mines of Schlangenberg as well as in Barnaul. Farther south they were observed between Lake Balkash and the Dsaisang Lake. In the great depression of Turkestan, the reactions of the Himalaya unite with those of Thian-chan, Kuenlun, and Bolor, and, what is very remarkable, concussions sometimes extend right across these lofty snow-clad mountains. Sir Alexander Burnes has shown that the earthquake which he experienced at Lahore, on the 22d January 1832, passed through the chain of the Hindoo-Koosh, in a direction from south-south-east to north-north-west, destroying the villages at Badakchan and those of the Upper Oxus, while it extended still farther towards Bokhara and Kokand.[5] The Ouralian Mountains have long been considered exempt from subterranean commotions, but recently (1836-37) shocks have been felt in the southern districts, at Slatoust, Kychtimsk, and Turdojak near Minsk. Whether these were produced by a continuation of the undulating motions which frequently extend through the line of the Caspian Sea to Astrakhan, and probably even to Moscow, is not ascertained.

Earthquake Districts of India.—Between the years 1800 and 1842 one hundred and sixty-two earthquakes are on record.[6] In 1843, twenty-three were observed, and since that time, four or five have occurred in India each year. Of the latter, the only violent ones were those of May 26, 1848, January 24, and March 31, 1852. Their geographical distribution was as follows:—Fifty-five occurred in the districts of the Central Himalaya, seventy-two in those of the Lateral Himalaya, including Cabool, Jellalabad, Cashmere, Nepaul, and Assam. In Assam alone thirteen are recorded between January 1839 and October 1842. In the Solimaun mountains one, in the Aravulli mountains eleven, delta of the Indus one, Vindhya mountains four, delta of the Ganges five, eastern shore of the Bay of Bengal twelve, western Ghauts two. Of one hundred and forty-four shocks, ninety-three occurred between May and October, or during the summer and rainy season; forty-two during winter and spring, and most of the remainder in the first half of the year. Earthquakes very seldom occur in the peninsula of India south of latitude 15°. In Ceylon, a violent shock occurred in 1833, one on June 19, 1843, and another November 11, 1848. The districts of some of the most recent and best known of these are inserted in the Plate in chronological order (see enlarged map of Northern India, to which the numbers refer).

(1.) 1819—June 16. By this shock, the Ullah Bund, a mound seventy miles long and sixteen miles broad, was elevated to a height of one hundred feet; the Runn of Cutch was sunk, and a salt-marsh with an area of two hundred miles was formed; the village of Sindree was submerged, the cities of Ahmedabad and Bhooj nearly ruined, and every building in the province injured. At Ahmedabad, five hundred of a marriage-party were killed; and at Bhooj two thousand persons perished.

(2.) 1833—August 26. Extended in the mountains from longitude 80° to 87° east; in the plains from Delhi to Chittagong, and from latitude 22° to 29° north, an area equal to four times that of the British Isles. The undulatory movement was from north-west to south-east. In the valley of Nepaul, four thousand houses were overturned, four hundred and fourteen persons killed, and one hundred and seventy-two wounded.

(3.) 1842—February 19. The shock was felt from Cabool to Mynpoorie, over an area of two hundred and sixteen thousand square miles; general movement from east to west, parallel with the ridge of the Himalayas. A third part of the town of Jellalabad was demolished, and all the parapets and guard-houses were levelled. In the space of little more than a month, one hundred earthquakes occurred in this quarter.

(4.) 1842—November 11. In this earthquake Calcutta was nearly the centre of emanation; the shock extended to Darjeeling on the north, Chittagong on the east, and Monghyr on the west. On the south it was felt on board of the Agincourt, seventy miles south of the floating light.

(5.) 1848—May 26. Mount Aboo was about the centre of emanation, and the shock extended in a direction nearly east to west, from Surat in the south to Simla in the north, over an area of about one hundred thousand square miles.

(6.) 1852—March 31. This earthquake extended from Simla to Jubbulpoor, over a nearly circular area of one hundred and ninety thousand miles. The shock was felt at different places, in almost opposite directions: the axis of emanation presenting a curved line in the form of the letter *f*, nearly parallel to the Himalaya range.

(7.) 1852—January 24. Occurred in the Murree country, extending through Khangur, Dadur, and all along the hill frontier. The fort of Khoun was levelled, and three hundred persons killed; the passes of Nuffoosk were blocked up, and the flow of the Theree river was extended far into the plains.

The next in order is the Earthquake district of Iceland, the boundaries of which it is more difficult to determine. Probably it includes the whole of Great Britain, and even the northern portions of France, Denmark, and Scandinavia, and extends to Greenland on the north and west. But though, for convenience of arrangement, it may be considered as forming a district by itself, it must not be regarded as unconnected with the others by which it is surrounded.[7] As an instance of the connection subsisting between this and the Mediterranean district, it may be sufficient to notice the remarkable coincidence as to time, in the great eruption of Scaptar Jökul of 1783 with that of the earthquake of Calabria in the same year.

In the remaining part of the Old World shocks of earthquakes have been observed in almost every explored region, but they occur chiefly, as might have been expected, in the vicinity of the volcanic girdle which surrounds it on the south-west. The activity of the volcanic series of the Sunda Islands has recently been manifested by the occurrence of an earthquake at Assam. One of the most frightful phenomena connected with this series was the *eruption of Tumboro*, in the Island of Sumbawa, in 1815, the concussions of which were felt in the Island of Sumatra and in the Moluccas.

As the interior of *Africa* is not known to possess any volcanic vents (Russegger having shown that the supposed volcano of Koldaghi in Kordofan does not exist), so, with the exception of a part of Barbary on the north, the regions of the Red Sea on the east, and the Cape Colony on the south, earthquakes are as yet unascertained in this vast continent. At the sources of the river Gambia it is reported that there are many traces of volcanic action, and that shocks of earthquakes are of frequent occurrence. In the years 1809 and 1811, slight shocks were experienced at the Cape of Good Hope.

The number of earthquakes which have occurred in Europe and the western parts of Asia, from A.D. 306 to 1844, arranged according to the seasons of the year in which they occurred, are[8]—

	Winter.	Spring.	Summer.	Autumn.	Total.
A.D. 306 to 1844, ...	876	640	673	784	2973
A.D. 1801 to 1843, ...	291	169	224	230	914

CHRONOLOGICAL LIST OF EARTHQUAKES WHICH HAVE OCCURRED IN GREAT BRITAIN.

A.D.		
974		First recorded earthquake in England.
1043		Another, on doubtful authority.
1048	On May 1.	Felt in Worcester, Derby, and many other parts of England, followed by great mortality of men and animals.
1076	Mar. & Apr.	Shocks, accompanied by subterranean noise, throughout all England.
1081	March.	Shocks, with subterranean noise, throughout England.
1089	Aug. 11.	Throughout all England.
1110		In Shrewsbury and Nottingham, for a whole day. The river Trent stopped flowing for a mile in length, and its channel became dry.
1115		Earthquakes of long continuance in Italy, and said to have been felt in England.
1133		Very violent shocks, preceded by loud noises.
1134		On the coasts of England and the Netherlands the sea rose suddenly, inundated the country, and again suddenly retired.
1142		Three shocks in one day felt in Lincolnshire.
1158		Violent in Syria; felt in London and other parts of England. The bed of the Thames dried up, so that the channel could be crossed on foot.
1165 or 1164?		In Norfolk, Suffolk, and Ely?
1179		Near Arlington, Durham, earth swelled up and sunk again with great noises.
1180		Two or three shocks in England.
1185	April.	Throughout all England. Lincoln Cathedral destroyed.
1186	In Autumn.	Throughout Europe. Houses were thrown down in England.
1199		Shocks, principally in Somersetshire.
1201	January.	In York and vicinity, accompanied by noise. Again in May, in Suffolk and Norfolk.
1202		Felt in different parts of England.
1218		Shocks felt.
1219		Do.
1240	June 1.	In England, especially in Kent.
1247	February 13.	In London and other parts. December 21, Cathedral of Bath and Wells much injured.
1250		Felt at St Albans and Chilterns, Hertfordshire.
1274	December 5.	Throughout England, accompanied by thunderstorms. A comet seen [illegible]
1275		Through England; many churches and cathedrals suffered.
1278		In England and France.
1284		In England.
1382	May 21, 24.	Prevailed throughout Europe, and very violent in England and sea-coasts.
1385	July 15.	A shock, followed by another, in this year.
1426	Sept. 28.	Seven shocks, for two hours, throughout Great Britain, preceded by a dreadful tempest.
1551	May 25.	Many shocks at Rygate, Croydon, and Dorking, Surrey.
1574	Feb. 26.	Very violent in the central counties from Bristol to York.
1575	July 27.	The tide in the Thames ebbed and flowed twice within an hour.
1580	April 6.	Throughout England, but especially from London to Dover, and in France, Belgium, &c. A return of the earthquake occurred on May 1.
1583	Jan. 13.	Commotions of surface in Dorsetshire, accompanied by a landslip of more than three acres, which moved 500 feet
1597	July 23.	Shocks at Perth and other parts of Scotland.
1601	Dec. 24.	At London.
1608	Nov. 8.	At Aberdeen.
1609	Jan. 19.	A flux and reflux of the tide in the Thames twice within an hour.
1638	End of year.	At Chichester several shocks, doing great damage, and accompanied by dense clouds and smell of pitch and sulphur.
1657	July 8.	In Parish of Barnley, Suffolk, preceded by a noise like thunder.
1665	January 18.	At Oxford, Coventry, Brill, &c.
1671	September.	On the coasts of the English Channel and German Ocean.
1678	January 5.	At Hanbury, borders of Derbyshire, and Wolverhampton, Staffordshire; and again in several places—Oct. 20 and Nov. 14.
1680	January 4.	At Chedzoy, Somersetshire.
1683	Sept. 2? and Oct. 9.	shocks at Oxford, and within a circuit of seventy miles, accompanied by low noises like prolonged thunder.
1690	October 17.	In Dublin and Kilkenny, Ireland; December 15, in Bedfordshire; and Sutherlandshire, Scotland.

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[1] When fractures are formed in a volcanic mountain, in consequence of the earthquake by which the eruption is preceded, the boiling lava from the central chimney is [illegible] generally terminates in opening for the lava a passage by which it flows laterally down the sides of the mountain [illegible] *Recherches sur la Structure du Mont Etna.* Spallanzani calculates that of thirty lava eruptions from Mount Etna, only two [illegible] crater itself; and [illegible] says that nine-tenths of all its eruptions were from the sides of the mountain.

[2] The velocity with which lava streams move [illegible] not only on the inclination of the soil, but also on the quantity and viscosity of the mass; one thousand feet per [illegible] of velocity, although as much as two thousand feet per hour has been observed, though rarely. The [illegible] in the lava-stream which broke out at the foot of Mount Etna, and continued to flow ten years, [illegible] two leagues (equal to two geographical) miles. Not less remarkable is the extreme slowness with which lava parts with [illegible] that exposure to the air quickly hardens its surface. During the destruction of Torre del Greco (1794), [illegible] a moving stream of lava which had flowed for twelve hours; and Sir W. Hamilton walked over a lava stream, flowing [illegible] sixty feet broad, at a distance of only one thousand feet from the centre. The heat is so concentrated in the interior [illegible] it is retained, with little diminution, for many years. The strongest example of this retention is furnished by the volcano [illegible] mass of lava, four hundred feet thick, was found smoking when visited by Alexander von Humboldt (1803), forty-five years after its eruption, and smoke was observed to issue from it when visited by Burkhart in 1827, sixty-eight years after it was expelled from the crater.

[3] During the eruption of Hekla in 1766, smoke and clouds of ashes obscured the sunbeams to such an extent, that in Glaumbær, about one hundred miles distant, men could only find their way by groping; and during the eruption of Coseguina (1835), the sky was so obscured that at Nicaragua, one hundred and fifty-five miles south-east, and at Matagalpa, one hundred and forty miles to the north-east, the inhabitants were obliged to make use of artificial lights at mid-day. The distance to which ashes are carried is still more considerable. Of this we have a striking example in the recent eruption of Hekla (2d September 1845), when the fall of ashes extended to the Orkney Islands—a distance of nearly seven hundred miles; and from an eruption of the volcano of Tomboro, in the Island of Sumbawa (1815), the ashes were carried to Bencoolen, a distance of eleven hundred miles—which is, in regard to distance, as if the ashes of Vesuvius had fallen at Birmingham.

[4] Geschichte der durch Ueberlieferung nachgewiesenen natürlichen Veränderungen der Erdoberfläche.

[5] A. von Humboldt, Central Asien, B. I., s. 426.

[6] Memoir by Captain Baird Smith.

[7] K. E. A. von Hoff, Geschichte der natürlichen Veränderungen der Erdoberfläche, ii. p. [illegible]

[8] Perrey in Comptes Rendus.

A.D.		
1692	Sept. 8.	At Deal, Canterbury, Sandwich, and Portsmouth; lasted six minutes.
1696		At Falmouth.
1704	January 8.	A sudden shock, preceded by a violent tempest; felt most violently at Lincoln, Hull, Beverley, South Dalton, and more feebly at Selby.
1726	Nov. 6.	A smart shock at Ilchester.
1732	December 1.	At Strontian, and along the west coast of Scotland.
1734	November 5.	In Sussex and south of England; also France, Ireland, &c.
1735	May 1.	In Ochil Hills, Scotland; two shocks, with noises.
1748	July 12.	South of England.
1750	January 19.	Eltham in Kent, two shocks from east to west; and on February 19, March 10, 19, 20, and April 13, other shocks in London, Chelsea, Epsom, &c.; on October 11, four smart shocks, extending over the Midland Counties.
1752	February 23.	Dartmoor and vicinity; April 16, Somerset.
1753	July, Sept.	Repeated shocks in various parts of England.
1754	April 19.	At York and vicinity.
1755	November 1.	Slight shocks in Britain, and disturbance of the sea and lakes, felt synchronous with the Lisbon earthquake; Nov. 7, at Whitehaven, and other places, in Cumberland.
..	Nov. 18.	At Gleman, Hertfordshire, a violent shock.
..	Dec. 31.	At Glasgow, Dumbarton, and other places, three consecutive shocks.
1756	February 18.	Synchronous with shocks throughout Europe; agitation prevailed from London to Glasgow; weather calm, followed by tempest.
..	Nov. 17.	Argyllshire—shock, with rumbling noise, lasted twenty seconds.
1758	January 24.	In Sussex and Surrey, slight tremblings.
..	Dec. 28.	London and neighbourhood, slight shock.
1761	March 31.	Synchronous with violent earthquake at Lisbon; shock felt at Cork, Ireland; the waters of Loch Ness were agitated to the height of two and a half feet for three quarters of an hour.
1767	April 29.	Stirling, and to the westward—a slight shock.
1768	January 5.	Crick, Northamptonshire—shock lasted 1½ minutes.
..	March 15.	Newcastle, Manchester, Darlington, Kendal, and places in Yorkshire—two shocks felt at intervals of half a minute; direction supposed east to west.
..	June 21.	Worcester, Gloucester, and many other parts of England, and in mountains of Scotland—a violent shock; Gloucester Cathedral shaken.
..	June 29.	In Bytun, Hertfordshire, a cleft opened in a hill in vicinity, and water gushed out. In same year the sea off Shetland Isles became turbid, and dead fishes rose to the surface.
1769	November.	In Inverness several houses were thrown down by a shock.
1776		During the year an earthquake felt at Inverness.
1777	Sept. 14.	Three shocks during half a minute, with loud noise, felt violently at Manchester, and less so at Lancaster, Liverpool, Birmingham, Derby, Chester, York, over a space of 140 miles. Direction south-west to north-east.
1780	Aug. 28, 29.	Shocks felt through Wales; December 9, throughout north of England.
1781	August 29.	Shocks through Wales.
1782	Oct. 5-18.	Shocks in Wales; Loch Rannoch, Scotland, agitated; barometer very much depressed.
1784	Sept. 12.	Loch Tay, Scotland, greatly agitated; water ebbed and flowed 300 feet for two hours, the agitation returning daily for a week.
1786	June 16.	Shocks—Isle of Man; August 11, shocks, with noise, through south of Scotland.
1787	Jan. 6-26.	Shocks in Perthshire, Scotland.
1789	July to Nov.	Repeated shocks—Comrie and Crieff, Scotland.
1791	Sept. to Oct.	Shocks in Leicestershire, Derby, &c., England; Crieff and Comrie, Scotland.
1793	Feb. to Sept.	Several violent shocks at Comrie, Salisbury, and Shaftesbury.
1794	May to Dec.	Several violent shocks at Comrie.
1795	Jan. to Oct.	Several violent shocks at Comrie; Nov. 18, a shock felt throughout south of England, from south-west to north-east, accompanied by low barometer, thunderstorm, and meteor.
1796		Repeated shocks at Comrie during years 1796, 1797, 1798, 1799, and 1800.
1801	January 11.	Two violent shocks, felt at Comrie and vicinity, extending to Edinburgh.
..	September 7.	Violent shock, accompanied by loud noise; extended from Comrie to Edinburgh and Glasgow; ground agitated, and several houses thrown down.
1809	January.	Shocks at Comrie, and Strontian, Argyllshire.
1811	Oct., Nov.	Oscillations, with rumbling noise, in Wales, Oxfordshire, and Portsmouth.
1812	January.	A smart shock felt in Oxfordshire and other parts of mid-England.
1816	March 17.	Smart shock and noise in Lincolnshire, Doncaster, Nottingham.
..	August 6.	At Perth, Carse of Gowrie, Strathearn; August 13, a shock distinctly felt in north of Scotland, from Tay to Pentland Firth—direction from north-west to south-east; greatest intensity in Inverness; spire of jail rent and twisted, Mason Lodge rent from top to bottom, and chimneys thrown down. At Montrose, shock accompanied by vivid flash of lightning. The summer had been excessively wet.
1817	April 28.	Smart shock felt at Inverness, Glasgow, Greenock, and slightly at Leith.
1818		Several shocks in England and north of Scotland felt this year.
1819	November.	Smart shock at Comrie.
1820	May.	Shock—Dumfries and Wanlockhead; Nov. 28, do., Leadhills.
1821	Oct., Nov.	Shocks—Crieff, Leadhills, and Wanlockhead.
1822	March.	Smart shock near York; April 13, very severe at Comrie.
..	Sept. 18.	Smart shock—Dunston, Newcastle-on-Tyne.
1827	February 9.	Shock in north-west of Wales and Anglesea; Ripon, Yorkshire.
1828	May 20.	Shock in south of Scotland.
1832	Sept. 18.	Shock at Chichester, Dorsetshire; Nov. 13, do.
1834	January 23.	Shock at Longfleet, near Poole, Dorset, accompanied by thunderstorm.
1838	January.	At Tynehead, shock, and rent formed half a mile long.
	March 17.	Shocks at Shrewsbury.
1839	March 29.	Smart shock—Glengarry, Inverness-shire; May 24, two shocks at Crieff; September 1, smart shocks at Bristol; October, November, December, at Comrie almost daily shocks—very violent on 7th, 8th, 10th, and 12th of October.
1840		During the whole of this year almost daily oscillations and noises at Comrie.
1841		Almost every month shocks at Comrie; very severe 10th and 23d October.

II. EARTHQUAKES OF THE NEW WORLD.

The earthquakes of the New World are, both as regards extent and frequency, equal to those of the Old World. They occur chiefly along the coasts on the western side of the chain of the Andes, and on the northern declivity of the mountains of Venezuela. Very few earthquakes are known to have occurred to the eastward of the chain of the Andes; and this circumstance confirms the fact already mentioned, that earthquakes do not occur generally in the vicinity of active volcanoes, but rather at a distance from them, as exemplified in the very frequent shocks experienced in the vicinity of Lima. Surveying the map from south to north, we find, first, the region of the great and recent *earthquake of Chile or Conception, 20th February* 1835. This earthquake was everywhere felt between the Island of Chiloe on the south, and Copiapo on the north, and from the Island of Juan Fernandez on the west, to Mendoza on the east of the Andes. Almost all the towns and villages situated between latitude 35° and 38° south were destroyed; and while Juan Fernandez suffered from its effects, and a shock was felt in the sea in its vicinity, the city of Valparaiso, situated in nearly the same latitude, was left untouched. During the progress of this earthquake, or immediately after its occurrence, the volcanoes opposite the Island of Chiloe, viz., Osorno, Minchinmadova, Corcobado, and Yanteles, as well as several others in the interior of the Chile range, were in a state of the greatest commotion.

The great *earthquake of Caraccas, 26th March* 1812, the concussions of which, like that of Lisbon, formed an ellipse, extended in a direction east-north-east to west-south-west, from Caraccas and Guayra to the high mountains of Niquitao and Merida, where it appears to have been most violent, although it was felt from near Bogota in the west to the Gulf of Paria in the east—forming part of the district which, as A. von Humboldt has so clearly demonstrated, was almost simultaneously shaken by convulsions from 1811 to 1813. The principal phenomena occurred in the following chronological order:—

January 30, 1811—Appearance of the Island Sabrina, near the Azores, which increased in size to the 15th June of the same year.

May 1811—Commencement of the earthquakes on the Island of St Vincent, which continued till May 1812.

December 16, 1811—Commencement of the concussions in the valleys of the Mississippi and Ohio, which continued till 1813.

December 1811—An earthquake in Caraccas.

March 26, 1812—The great earthquake of Caraccas, which continued till 1813.

April 30, 1812—Eruption of the volcano of St Vincent; and on the same day subterranean sounds heard in Caraccas, and on the banks of the Rio Apure.

Another great phenomenon of tropical America was the *eruption of Cosiguina* and the *synchronous earthquake of New Granada* in the beginning of 1835. The eruption of Cosiguina, from which, as already observed, the ashes were carried to such an amazing distance, occurred on the 20th January, and a few weeks afterwards, almost the whole of New Granada was violently convulsed; the subterranean thunder was heard simultaneously in Popayan, Bogota, Santa Marta, Caraccas, Haiti, Jamaica, Curaçao, and in Lake Nicaragua.

The Earthquake of Guadeloupe, February 8, 1843.—This earthquake, for the local phenomena which it displayed, and the general laws of earthquake motion which it illustrates, is one of the most interesting on record. It was felt over a long and relatively narrow zone, from New York in the United States to the Island of Marajo, at the mouth of the river Amazon, a space of three thousand miles; but the violent concussion was confined to the Antilles, where, from St Christopher and Antigua on the north, to St Vincent and Barbadoes on the south, the whole volcanic belt was severely shaken. The maximum intensity of the movement was in the islands of Guadeloupe and Antigua, where it either prostrated or greatly damaged almost every structure. The town of Point-à-Pitre in Guadeloupe was entirely overthrown, and 6000 of its people destroyed. Here the earth opened in several places, columns or sheets of water spouting from the cracks a hundred feet high, the chasms closing again and ingulfing men and objects; and the same opening and shutting of the crust occurred also in Antigua. In both islands, and indeed in all where the motion was vehement, the ground reeled to and fro; and this movement had the character of a regular but rapid undulation, attended by a tremulous vibration or strong convulsive jar. At places remoter from the centre of violence, as Martinique, St Vincent, Barbadoes, Grenada, and Trinidad, the same phenomena were apparent, but in diminished force—the wave-like heaving of the earth extending, however, to limits far beyond those where the concussion or tremulous jar ceased to be felt. Wherever the undulation was especially energetic, the ground gaped and closed alternately in numerous parallel fissures, through which warm water, steam, and sulphurous vapours gushed forth. At St Bartholomew a great fissure yawned, a foot in width and six hundred yards in length.

A comparison of the exact dates of the passage, at different points, of the earthquake the whole duration of which seems nowhere to have exceeded three minutes, leads to the interesting deduction, that it agitated *simultaneously* a long narrow belt or line, extending in a N.N.W. and S.S.E. direction through the Antilles to Bermuda on the north, and to Guiana, or even to the river Amazon, on the south; while to the east and west it came later in time, as the points were more remote. The width of the area shaken was much greater in its northern half than in its central and southern portions, as a glance at the Plate representing the probable limits of this earthquake will show.[1] Thus it was felt, though with greatly enfeebled force, along the coast of the United States from Savannah to New York, a distance from Bermuda, on its line of maximum energy, of 750 or 800 miles; and it also extended in the same direction to Turk's Island; but in the latitudes most violently convulsed, the agitated district was much narrower, for there it reached no further westward than Porto Rico. This wider extension of the undulation north of the West Indies seems obviously connected with the absence of any volcanic vents there, the presence of which in the Windward Islands, by allowing a more prompt relief to the tension engendering the earthquake, may probably, as in so many instances of violent earthquakes near volcanoes, have limited the transmission of the wave. Though synchronous, or nearly so, throughout a line some 2500 miles long, coincident with the great volcanic fissure on which the Windward Islands are seated, the shock or pulsation took 29 or 30 minutes to travel from this axis to the Atlantic coast of the United States. It possessed a progressive motion, therefore, of 25 or 27 miles per minute.

In the West Indies the ground undulated violently between north-east and south-west directions, coinciding approximately with the course right and left of the pulsation from the line whence it seems to have started. But at Columbia, South Carolina, and other points near the coast of the United States, the rocking motion was W.N.W. and E.S.E.—a direction here equally accordant with the general line of the outward flow of the earthquake waves as they struck these shores. In harmony with the oscillation last mentioned is the fact that the earthquake was very nearly simultaneous along the N.N.E. and S.S.W. line of the sea-board from New York to Savannah.

The *eastern side of the United States* is a region where the earthquakes, though seldom violent, present their essential phenomena over areas so wide and in such distinctness as to afford some valuable general facts towards the true natural history of these convulsions of the crust. It is estimated that more than one hundred separate earthquakes have been noticed, within the past two hundred years, in the earlier peopled districts. One interesting fact, belonging to the agitations of probably the whole Apallachian region of the Continent, is the prevailing S.E. and N.W. direction of the oscillations of the ground. This was noticed nearly one hundred years ago,[2] and observations on all the more recent earthquakes confirm it. A true undulatory movement is their usual concomitant; and it is worthy of note that the deep subterranean roar or wide-rushing noise, which announces these earthquakes, and is sometimes their chief symptom, is almost invariably heard to pass in the direction of the oscillations and of the progress of the shock, as from S.E. to N.W., or the converse. Often this sound has been heard coming from the one quarter in advance of any vibration or heaving of the earth, and then dying away in the opposite direction after their cessation.

Among the most conspicuous modern earthquakes of this side of North America was that which disturbed the valley of the Mississippi in the year 1812. This was rather a long series of concussions beginning late in 1811, and lasting at intervals for more than a year. It resulted in the permanent submergence of an extensive tract bordering the west side of the river Mississippi near New Madrid, through a length of some seventy-five miles north and south, by thirty miles east and west.[3] This large tract of drowned land was permanently undulated in level, the low broad swells and troughs observing in general a north and south direction.[4] During the shocks great chasms opened in the earth, some of which are still visible; and these were generally seen to yawn in lines running S.W. and N.E.[5] The small map of the earthquake region of the United States exhibits the position of the permanently altered ground, and indicates another district of frequent pulsations. This latter embraces the sea-board of the New England States, and may be approximately and vaguely limited between the Penobscot and the Delaware, and between the Atlantic and the valley of the St Lawrence. Within this area a more restricted narrow zone of country, a little inland from the coast of New Hampshire, is the seat of very numerous feeble undulations and tremblings; and another such focus of action seems to be in Haddam, Connecticut.

Earthquake from the Mississippi River to the Atlantic Coast, January 4, 1843.—The best characterised recent earthquake of the United States was that of January 4, 1843, the limits and other chief elements of which are indicated on the Earthquake Chart. It occurred at the tranquil hour of 9 o'clock in the evening, and was perceptibly felt, and its dates of passage noted, with more or less precision, from Ohio and Iowa to Louisiana and Georgia, and from the western frontiers of Missouri and Arkansas to the Atlantic coast. Throughout the greater portion of this area both the regular undulation and the vibratory jar were distinctly felt. Where the noise was heard, this was noticed to come from the westward, or to die away towards the eastward, and the oscillation of the earth was distinctly observed to be from the west towards the east likewise. It was such in some places as to rock the houses, swing pendulous objects, and to stop the clocks—thus recording its own advent. Its duration was generally reported at about two minutes. Strongest in the region of the Mississippi Valley, it seemed to decline in energy as it moved to the Atlantic coast. That it advanced from west to east, in the manner of a long and nearly straight wave, or rather of a belt of broad, flat, quickly-passing billows beneath or within the crust, has been proved by a comparison of the epochs of the shock, as it overtook the different places in its progress. It was felt almost simultaneously (as indicated in the Map) along a N.N.E. and S.S.W. line some five hundred miles in length, extending from Illinois, through St Louis, to Arkansas; and in about eight and a half minutes it had reached another parallel line of places about 270 miles more to the E.S.E., along which it was equally synchronous as along the first. Simultaneously again it touched the line of the sea-board cities from New York to Savannah, but was about eleven and a quarter minutes in reaching this position from the middle line of stations passed. Both sets of elements give nearly the same progressive speed—namely, thirty-three miles per minute. Where this earthquake originated has not been ascertained; but the elements here given are authenticated by some twenty-seven good observations.

b. GEOGRAPHICAL DISTRIBUTION OF VOLCANOES.

On examining the accompanying map, it will be found that volcanoes are distributed over every part of the globe—that they occur in all latitudes, under every zone, entirely independent of climatic differences. Organic nature gives to each region of the earth the peculiar physiognomy by which it is characterised, but it is very different with inorganic nature, in those places where the solid crust of the earth is devoid of vegetation. In the latter we everywhere see the same laws of formation proclaiming themselves—the same kinds of rocks attracting or repelling each other in groups, are found in both hemispheres, from the equator to the poles; and it is especially in the phenomena of volcanoes that we are struck with this general identity of form and structure. When the European navigator, far from his native country, finds himself under skies where strange stars have replaced the constellations to which he is accustomed, and he is surrounded by the forms of an exotic flora, he still recognises forms which recall to him the dome-shaped summits of the mountains of Auvergne, the craters of elevation of the Canaries, and the eruptive fissures of Iceland.

One great fact in the distribution of volcanoes is, that by far the greater number are found on islands or on sea-coasts: this, and the occasional occurrence of submarine eruptions, early led to the opinion that volcanic action is dependent on vicinity to the sea. But the existence, in the New World, of the three volcanoes of Jorullo, Popocatepetl, and Fragua, situated respectively at eighty, one hundred and thirty-two, and one hundred and fifty-six geographical miles from the shores of the ocean; and in Central Asia the volcanoes of Thian-chan, or the Celestial Mountains, situated at about fifteen hundred miles from the nearest sea, warrant the conclusion that volcanic action does not depend on the vicinity of the sea, nor on the introduction of water into the interior regions. If coast lands appear to offer a position favourable to eruptions, it seems to be because they form the sides of profound basins occupied by the sea, which, covered with water, and situated many thousand feet below the interior of continents, present comparatively little resistance to subterranean forces.

Independent of the influence of climate in their geographical distribution, volcanoes have been ranged in two classes essentially different—the *central volcanoes* and the *volcanic chains* or *linear volcanoes*; according as they form the centre of a group of eruptions regularly disposed in every direction, or compose a connected line in which they are ranged at short distances in the same direction, like vents upon an extensive fissure. The Peak of Teneriffe is an example of a central volcano; it is the centre of a group to which the volcanic isles of Palma and Lanzarote belong; whilst the chain of the Andes, that immense natural rampart, extending from Southern Chile to the north-west coast of America, sometimes as a single range, and sometimes divided into two or three parallel branches, united at intervals by narrow transversal articulations, presents, on a grand scale, an example of a volcanic chain, or series of linear volcanoes situated on a continent.

Exact inquiries into the distribution and arrangement of present and formerly-existing volcanic vents are of the greatest importance to a knowledge of the physical properties of the globe, since the existence of numerous islands, and the formation of entire continents, is clearly to be traced to volcanic action. In order to present these different systems in one general view, we have prepared the following table, which exhibits the relative position of each volcano, with the system to which it belongs, distinguishing those which are active from those which are extinct, the date of last eruption, and the elevation above the mean level of the sea.

It is extremely difficult to form even an approximate estimate of the number of active volcanoes existing on the face of the globe at any fixed period of time; for while one traveller considers some of them as extinct, another affirms that they are in a state of activity; many observers, not accustomed to such phenomena, frequently mistake solfataras and hot springs for volcanoes, and we are obliged to trust to vague and often very unsatisfactory reports for the fact of their existence in remote and unexplored regions. We have been at great pains to render the table as complete as in these circumstances it was possible to make it, by collecting from every accredited source all existing observations, and distinguishing by marks of interrogation those which are more or less doubtful. The number of active volcanoes thus ascertained is two hundred and seventy, of which by far the greater part—namely, about one hundred and ninety—are found on the islands or around the shores of the Pacific Ocean.

THE VOLCANIC PHENOMENA OF CENTRAL ASIA.—In the following notice of this extensive and little-known territory, we shall endeavour to present an outline of the results of the elaborate researches of A. von Humboldt, who, in his "Asie Centrale," has given a complete picture of these phenomena from obscure and inaccessible Eastern authorities. The mountain system of Thian-chan, or the Celestial Mountains, forms the central line of volcanic activity; nearly in the middle of this great range, and on its northern declivity, rises the volcano of Pe-shan (white mountain), called Ho-chan and Aghie by the Chinese, and Echikbash by the Turks. Farther to the east, at a distance of six hundred and seventy miles on the southern declivity, between Turfan and Pidjan, lies the volcano of Ho-tcheou (burning mountain). Both of these are isolated cones, and the only proper volcanoes of Central Asia which are ascertained to be in a state of activity: near the same range of mountains, and in an intermediate position, there occurs only the *solfatara of Ouroumtsi*.

Farther northwards, in the basin which separates the Thian-chan from the chain of the Altai on the one side, and from the much less elevated territory which extends to the chain of the Oural and the Caspian Sea on the other, are found the following points which form an evident connection between the interior of the earth and the atmosphere, and which appear to be dependent on the activity of the central line of Thian-chan. At the distance of fifty miles north-north-west from the volcano of Pe-shan, we find the hot springs of *Arashan*, and at about seventy miles farther towards the north-north-west, south of the river Ili, rises the Mount *Kholak*, on the declivity of which sal-ammoniac is gathered in the fissures of the rocks. To the northward of Lake Alatku-kul, and in a line nearly parallel with the Thian-chan, lies the mountain chain of Tarbagatai, which separates the basin of the above-named lake from that of Lake Dsaisang. At the eastern extremity of this range is situated *Mount Saurn*, which, according to Sievers, is volcanic, and which the Kirghiz assert emits smoke, and even flames. It produces a great quantity of sal-ammoniac and sulphur. About one hundred and fifty miles to the eastward of this is the hill of *Khobok*, in the middle of a plain, on the small river of the same name, which flows into Lake Darlai. Still connected with the system of the Altai, and south from Bielouka, its culminating point, there are recognised traces of subterranean activity in the spring of *Rachmanowka*, an eastern tributary of the Bouroul which flows into the Upper Bukhtarma, the temperature of which is 104° higher than the mean temperature of the atmosphere.

Besides these great and somewhat connected volcanic districts, there are still two isolated points which show traces of volcanic activity: the one is Strahlenberg's supposed great Siberian Volcano, situated in north latitude 64° 30,′ longitude 106° 20′ east, between the sources of the Olenek and Viloui rivers. The exaggerated accounts of this volcano having emitted flames, seem to have arisen from the appearance of the *fumaroles* (suffocating vapours, from which ammoniac is disengaged). The others are, the *field of fire*, a district near Bakou, on the western shores of the Caspian Sea, which continually emits inflammable gas; the mud volcanoes (*salsen*), or springs of naphtha, petroleum and mud, in the same vicinity; and the naphtha springs on the island of *Tcheleken* in the Caspian Sea.[6]

The *active volcanic vents of China* appear not to consist of proper volcanoes, at least it is not ascertained that any of them have ejected ashes or lava streams; but the agency of volcanic action is evinced in the numerous *Ho-shans* or fire-hills, and *Ho-tsings*, fire-springs, or wells of fire. The latter are artificial apertures sunk in the solid rock, to a depth varying from fifteen hundred to three thousand feet, with a breadth of five or six inches; the water procured from these wells contains a great portion of salt and nitre. On applying a lighted torch to some of these, whence there is no flow of water, fire issues forth with great violence and a noise like thunder, bursting into a flame twenty or thirty feet in height. The gas has a strong bituminous smell and burns with a bluish flame, yielding a great quantity of dense black smoke. Confined in bamboo tubes, this gas is employed in the evaporation of salt-water from the neighbouring springs. Similar volcanic vents, mud volcanoes, and fire-springs occur in India, about the region of the Indus, in the N.W., near the coast between Bombay and Goa, on the west; at Pondicherry on the S.E.; in Burmah (see Plate 2), and at the mouth of the Ganges on the east. The only known crater in Central India is at Lake Loonar.

d. NOTES ON THE RAISING AND SINKING OF CONTINENTS.

The phenomenon of the gradual and imperceptible change of the relative level of land and sea in countries situated at a distance from active volcanoes, and in which violent earthquakes are not known to have occurred within the historical era, is exemplified on the largest scale in Scandinavia.

1. *Raising.*—Through the whole of Norway, from Cape Lindesnäs in the south, to the extremity of the North Cape, the line which the ancient sea-coast attained previous to historical times is indicated by deposits of shells identical with those of the existing sea, which, according to the very careful measurements of Bravais, are found at a height of six hundred feet above the present mean level of the ocean. On the Swedish coast, the maximum of upheaving power appears to lie in Northern Lapland, to the north of the Gulf of Bothnia, and the level evidently diminishes gradually in proceeding southwards to Sölvitsborg; and here, on the parallel of 56° 3′ north, there is unquestionably a line crossing Sweden from east to west, along which the ground is perfectly stable, and has not changed its level for many centuries. To the south of this stationary line, however, or throughout the province of Scania (part of Cristianstad and Malmoehus), it is now clearly ascertained that the land is undergoing that gradual depression, the existence of which Mr Lyell first announced to the British public, and in proof of which Professor Nillson, who has devoted so much attention to this phenomenon, shows, among many other examples, that the village of Stafsten in Scania is now three hundred and eighty feet nearer the Baltic than it was in the time of Linnæus, by whom it was measured, eighty-seven years before. There are no sufficient data for estimating exactly the area subject to this upheaving movement in Norway, but it appears to extend from Götenburg to the North Cape, a space of nearly one thousand miles, over which the rate of elevation increases as we proceed northwards. Since trustworthy observations do not extend beyond a century and a half from the present time, it cannot be determined whether the rate of upheaving force is uniform during very long periods. As to the present amount of elevation, Lessing, from observations made at forty-six different points of the coast, extending along the east side of Sweden from Neder Kalix (latitude 55° 40′ north), and on the west side from Koön in Bahus Län (latitude 57° 43′ north) to the above-mentioned line at Solvitsburg in the south, estimates it at nearly four feet in a century; while A. von Humboldt reckons that a period of eight thousand years must have been necessary to raise the coast three hundred and fifty feet.

Forchhammer has shown that there is an upheaval of the coasts of Denmark, in the Sound as well as on the Island of Saltholm, opposite Copenhagen, and that the Island of Bornholm is rising at the rate of one foot in a century. Trevelyan also affirms that there is a process of upheaving apparent in Jütland, near Frederickshaven, or Flatstrand, not far from the Skagen. On the Prussian shores of the Baltic Berghaus calculates, from a comparison of the state of the sea at different places, that the coast at Memel has, within a period of thirty years (1811-1840), been raised one foot four inches. While, on the contrary, the coast at Pillau has in the same period sunk one and a half inch, and that at Swinemünde one and one-eighth inch. In our own island, Prestwick has shown that a process of upheaving is in operation on the coast of Banffshire, in the Moray Firth; and Trevelyan has called attention to a similar occurrence in the Channel Islands, especially at Guernsey.

2. *Sinking.*—The recent observations of Dr Pingel and Captain Graah confirm the opinion that a large portion of the coast of Greenland has been gradually sinking during the last four centuries. "Ancient buildings on low rocky islands and on the shore of the mainland, have been gradually submerged, and experience has taught the aboriginal Greenlander never to build his hut near the water's edge. The Moravian settlers have been obliged more than once to move inland the poles upon which their large boats were set, and the old poles still remain beneath the water as silent witnesses of the change." The area of this submergence extends as shown on the map, from Igalliko Fiord on the southern coast, latitude 60° 43′ north, over Julianen-haab, Frederick's-haab, the Fulluartalik Islands, and Godt-haab, to Napparsock, latitude 65° 20′ north, and probably even to Disko Bay, near latitude 69° north.

Besides the inconsiderable depression of the Prussian coast at Pillau and Swinemünde on the Baltic, as shown by Berghaus, Forchhammer has also, with con[illegible] [illegible]inty, shown that a part of the west coast of Denmark, especially between Husum and the Sch[illegible] [illegible] undergoing a similar change.[7]

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[1] See small Map, Earthquake Districts of United States and West India Islands.

[2] Professor Winthrop—"A Lecture on Earthquakes," 1755.

[3] Lyell's "Principles of Geology," 1850.

[4] Nicollet.

[5] Silliman's Journal.

[6] For mud volcanoes of Trinidad, see Plate 7.

[7] See Notes on Upheaval, page 16, and Map of the Island of [illegible] [illegible] of signs and colours, we note under the principal title of the Map. To this edition have been added a Map of [illegible] the United States and the West India Islands, and [illegible] of Denmark, one of the volcanic islands of the Grecian Archipelago, from a recent survey.

(Active Volcanoes distinguished by a star, thus *).

e. GEOGRAPHICAL DISTRIBUTION OF VOLCANOES OVER THE GLOBE.

(Volcanoes of doubtful activity, thus ? *—Vs. of doubtful existence, thus ? ?).

SYSTEMS.	CENTRAL GROUPS.	Geographical Position.		Date of last Eruption.	Height in Eng. feet.
		Latitude.	Longitude.		
	A. MEDITERRANEAN SEA.				
I. Etna,	*1. Etna in Sicily. (Macaluba, Mud V. in the SW. part of Sicily),	37° 45' N.	14° 50' E.	1852	10,874
II. Vesuvius,	*2. Vesuvius at Naples. (Epomeo in the I. of Ischia, extinct V.),	40. 48. 40	14. 27. 10	1846	3,948
III. Lipari Is.,	*3. Chicciola in the I. of Stromboli,	38. 47. 30	15. 13.		2,957
	*4. V. of Vulcano I.,	38. 24.	14. 57.		
	B. ATLANTIC OCEAN.				
IV. Jan Mayen,	*1. Mt. Beeren (Beerenberg) or Esk, in the I. of Jan Mayen,	70. 49.	7. 31. W.		6,874
	? *2. Volcano of the Egg or Bird's Island,	70. 20.	7. 30.		
V. Iceland,	*3. Leirhnukur,	65. 47.	16. 48.	1730	
	*4. Krabla,	65. 45.	16. 42.	1725	
	*5. Trölladyngur,	65. 20.	16. 44.	1510	
	*6. Herdubreid,	65. 21.	16. 09.	1717	
	*7. Oraefa Jökul,	64. 10.	16. 55.	1783	5,927
	*8. Hekla. (The Geysers are situated north-west of Mt. Hekla).	63. 59.	19. 42.	1845	5,210
	*9. Kötlugia or Myrdals Jökul,	63. 36.	18. 35.	1823	
	*10. Eyafialla or Oester Jökul,	63. 38.	19. 25.	1821	5,685
VI. Azores,	*11. El Pico in the I. of Pico,	38. 28.	28. 28. 30	1720	7,600
	12. V. of the I. Porto de Ilheo, south of S. Miguel,	37. 42.	25. 29. 30	1652	
VII. Canary Is.,	*13. Pico de Teyde (in the I. of Teneriffe,)	28. 17. 40	16. 39. 15		12,182
	14. Pico de Chahorra	28. 16. 30	16. 32. 45	1798	9,886
	15. Mte. de las Cabras in the I. of Palma,	28. 32. 30	17. 54.	1677	
	16. Vandama in the I. of Gran Canaria,	28. 03.	15. 25.		1,835
	17. Mte. de Atalaya in the I. of Fuerteventura,	28. 40.	13. 54.		
	18. Mns. de Fuego in the I. of Lanzarote,	29. 01. 05	13. 44.	1736	
	19. V. of the I. Alegranza,	29. 23. 30	13. 29. 30		939
VIII. Cape Verde Is.	*20. V. of the I. Fuego or Fogo,	14. 55.	24. 25.	1847	9,154
IX. Ascension I.	21. I. Ascension. (Green Mt. 2,818 feet high.)	7. 57. S.	14. 22.		
X. Tristan da C. Is.	? ? 22. V. of Tristan da Cunha I.,	37. 6.	12. 16		8,236
XI. Trinidad I.	23. V. of the I. Trinidad,	20. 31.	29. 19		
XII. Traverse Is.,	*24. V. of the Traverse Is.,				
	C. INDIAN OCEAN.				
XIII. Bourbon, &c.,	*1. V. of the I. of Bourbon,	20. 55.	55. 20. E.		8,236
	? ? 2. Piton du Milieu in the I. of Mauritius,	20. 10.	57. 30.		
	? ? 3. V. of the I. of Rodriguez,	19. 41.	63. 30.		
	D. PACIFIC OCEAN.				
XIV. Hawaii Archipelago,	? ? 1. Mauna Keah or White Mountain (in the I. of Hawaii,)	19. 50. N.	155. 30. W.		13,645
	*2. Mauna Worroray or Hualai	19. 44.	155. 56.		10,790
	*3. Mauna Roa Loa or Great Mountain	19. 27.	155. 45.	1843	13,120
	*4. Kilaueah or Great Volcano	19. 25.	155. 27.	1852	3,870
XV. Galapagos Is.,	*5. V. of Narborough I.,	0. 20. S.	91. 37.	1825	3,720
XVI. Marquesas Is.,	? ? 6. V. of Domenica or Ohivahoa,	9. 43.	138. 34.		? 3,000
XVII. Society Is.,	7. Tobreonou of the I. of Otaheite,	17. 37.	149. 27.		12,250
XVIII. Easter I.,	8. V. of Easter I.,	27. 06. 20	109. 12. 33		1,200
	E. ASIATIC CONTINENT.				
XIX. West. Asia,	*1. Demavend (Culminating point of El Burz Mts.),	35. 50. N.	52. 15. E.		14,695
	? ? 2. Ararat,	39. 42.	44. 20.		17,210
	? ? 3. Seilan-Dagh, or Sapan Tagh, north of Lake Van,	38. 35.	42. 40.		
	LINEAR VOLCANIC SERIES.				
	A. OLD WORLD.				
I. Greek Is.,	*1. I. Santorini,	36. 22.	25. 29. E.		
II. Tsian-chan,	*2. Peshan,	42. 05.	83. 25.	? 1600	
	*3. V. of Hotcheou,	43. 15.	90. 50.		
III. Red Sea,	*4. Jebel Tarr, Teir, or Teer, also J. Douhan,	15. 32. 50	41. 55.	1834	835
	5. V. of the Is. of Sabugar or Zebayr. (? Sagair & Harnish Is. Volc.),	15. 03.	42. 17. 15		
IV. Friendly Is.,	*6. V. of the I. Tufoa,	19. 46. S.	175. 06. W.		? 3,000
	*7. V. of the I. Amargura,	17. 57.	174. 30.		
V. Australian Series.	*1. Egmont in the northern Island of New Zealand,	39. 15.	174. 13. E.		8,840
	*2. Edgecombe in the White I. (Bay of Plenty),	38. 00.	177. 02.		9,630
	? *3. V. of Brimstone Island (according to Capt. Thayer),	30. 14.	178. 55.		
	*4. Mathew, or Matthew,	22. 22.	171. 15.	1828	
	*5. V. of Tanna, in the New Hebrides,	19. 30.	169. 29.	1774	454
	*6. V. of Ambrym, in the same Archipelago,	16. 15.	168. 20.		
	*7. V. of Volcano I., in the Isles of Santa Cruz,	10. 23. 30	165. 38.		? 200
	*8. V. of Sesarga, in the Salomon Isles,	9. 58.	160. 21. 30		? 12,000
	*9. V. of New Britain,	5. 12.	151. 50.		
	*10. V. on the east side of New Britain,	5. 25.	148. 16.		
	*11. V. on the northern coast of New Guinea, (seen by Dampier,)	4. 52.	145. 16.		
	*12. V. 12 miles from the northern coast of New Guinea	3. 55.	144. 15. 30		
	*13. V. on the north-western point of New Guinea	1. 25.	131. 19. 30		
VI. Sunda Isles,	*1. Wawani, in the I. of Amboina,	3. 40.	128. 20.		
	*2. Gounong Api (Burning Mt.) of Banda I.,	4. 30.	130. 00.		? 4,000
	*3. Seroa, Sorea or Cerowa,	6. 10.	129. 50.	1693	
	? ? *4. V. of Nila I.,	6. 56.	129. 51.		
	? *5. Dommas,	7. 20.	128. 36.		
	*6. Gounong Api,	6. 35.	126. 40.	1820	
	? ? 7. V. of Cambing or Passage I.,	8. 20.	125. 30.		
	*8. V. of Pantar I.,	? 8. 25.	124. 20.		
	? ? 9. V. of Lomblen (Lomblatta) I.,	8. 12.	123. 52.		
	10. Lobetobie, (Volcanoes of Floris I.,)	8. 35.	122. 48.		
	11. V. near the mid. of the island	8. 43.	121. 30.		
	12. V. near the southern coast	8. 52. 20	121. 10.		
	? ? 13. V. of Tower Island, south of Floris.	9. 09.	120. 36.		
	? ? 14. Cambyna (Probable Volc. of the southern coast of Celebes,)	4. 51.	121. 57.		
	? ? 15. Bole Comba	5. 30.	120. 09.		
	? ? 16. Bonthian	5. 28.	119. 45.		
	? *17. V. of Jindana or Sandalwood I.,	9. 20.	119. 18.		
	? ? 18. V. of Jilbanta I.,	8. 35.	119. 17.		
	*19. Gounong Api, in a small island near the NE. point of Sumbawa,	8. 11.	119. 05.		
	*20. Tumbora or Arona Mt. in the I. of Sumbawa,	8. 09.	117. 43.	1815	? 7,000
	*21. V. of Lombock I.,	8. 21. 30	116. 26.		8,000
	? *22. Kara Assam or Bali Peak, in the I. of Bali,	8. 24.	115. 24.	1808	
	*23. Idjeng or Taschem,	7. 26.	114. 12.	1817	5,000
	24. Ringgit,	7. 07.	113. 48. 30		3,400
	*25. Lamongan,	7. 50.	113. 24.	1808	
	26. Semeru,	8. 08.	113. 09.		13,000
	*27. Dasar,	7. 50.	113. 08.	1804	7,034
	*28. Walierang,	7. 42.	112. 35.		10,300
	29. Ardjuno,	7. 39.	112. 31.		10,641
	*30. Klut,	7. 56.	112. 16.	1785	7,000
	31. Wilis,	7. 48.	111. 51.		8,400
	32. Lawu, (Volcanoes)	7. 36.	111. 10.		10,727
	33. Djapara,	6. 36.	110. 57.		
	*34. Merapi,	7. 35.	110. 40.	1822	9,700
	35. Merbabu,	7. 26.	110. 35.	1562	10,220
	36. Ungarang,	7. 08.	110. 25.		7,100
	*37. Sumbing or Sunding,	7. 22.	110. 08.		11,020
	*38. Sindoro or Sadoro,	7. 15.	109. 56.		9,800
	*39. Slamat, Gedee or Tegal, (of the)	7. 13.	109. 10.		11,329
	The following Volc. form 2 distinct Series:—				
	a. Northern Series.				
	*40. Tjerimai or Tchermai,	6. 53.	108. 28.	1805	8,200
	41. Gounong Kraga,	7. 05.	108. 16.		
	42. Agung,	6. 57.	107. 58.		6,400
	43. Bukit Djarriang, (Island)	6. 54.	107. 54.		
	44. Manglayang,	6. 56.	107. 56.		
	45. Bukit Tungul or Tanggil,	6. 51.	107. 51.		7,200
	46. Guntur,	7. 14.	107. 47.		
	*47. Tankuban Prahu,	6. 51.	107. 39.		6,427
	48. Burangrang, Bumgrang or Burungiang,	6. 48.	107. 31.		5,690
	b. Southern Series.				
	*49. Galung Gung,	7. 20.	108. 12.	1822	
	*50. Talaga Bodas, (of)	7. 13.	108. 07.		5,490
	51. Tchikurai or Tchikura,	7. 33.	108. 01.		4,144
	*52. Papandayang,	7. 08.	107. 55.	1772	7,030
	53. Wayang or Wyahan,	7. 20.	107. 50.		6,149
	54. Malabar or Malawar,	7. 22.	107. 46.		7,556
	55. Sumbung,	7. 20.	107. 43.		5,582
	56. Tilu,	7. 14.	107. 23. 30		6,062
	*57. Patuha, Bodurwa or Patacka,	7. 05.	107. 20.		7,307
	58. Tambak-ruyung or Tombak-Pacyong. (Java.)	7. 13.	107. 14.		5,396
	*59. Gedee. (This Volcano unites the two series,)	6. 53.	106. 59.		9,850
	60. Salak,	6. 44.	106. 48.	1761	7,204
	61. Gagak,	6. 45.	106. 30.		
	62. Karang or Golgatha,	6. 21.	106. 02.		5,263
	63. Djali or Djalo,	6. 18. 30	105. 57.		
	64. Pulasari,	6. 29.	105. 58.		
	65. Djunging,	6. 19.	105. 32.		
	*66. V. of the I. Cracatoa or Rakata,	6. 05.	105. 25.	1680	
	*67. Gounong Dempo,	3. 54.	103. 00.		12,000
	*68. Gounong Api or Berapi,	1. 30.	101. 38.		8,000
	*69. Merapi, or Berapi,	0. 09.	100. 42.		13,200
	*70. Singallang or Sinkalang, (Vs. of the I. of Sumatra,)	0. 11.	100. 20.		15,000
	*71. Gounong Pasaman or Ophir,	0. 05. N.	99. 57.		13,840
	*72. Bongapit,	3. 42.	98. 10.		
	? ? 73. Mt. Elephant or Friar's Hood,	5. 07.	96. 58.		
	*74. V. of Barren I.,	12. 16. 30	93. 54.	1792	1,700
	75. V. of Narcondam I.,	13. 24.	94. 20.		
	*76. V. of I. Regnain,	18. 37. 30	93. 49. 30		90
	*77. V. of Cheduba I.,	18. 50.	93. 36.		
	*78. V. of Ramree I.,	19. 05.	93. 46.		
	The 2 following are isolated:—				
	*79. V. of Cape I., between New Guinea and Australia—(perhaps prolongation of the Sunda series),	9. 48. S.	142. 59.		
	*80. V. of Burning I., on the S.W. shore of Borneo,	3. 16. N.	112. 11.	1793	
VII. Molucca Is., Philippine Isles, and Formosa,	*1. V. of the I. Mackian,	0. 20.	127. 30.	1646	
	*2. V. of the Motir,	0. 30.	127. 22.		
	*3. V. in the southern part of Tidore I.,	0. 38.	127. 24.		
	*4. V. of Ternate I.,	0. 48.	127. 23.	1814	4,003
	? *5. V. at Gammacanore in the I. of Gilolo,	0. 42.	127. 35.	1673	
	*6. Tolo of the I. Mortay,	2. 44.	128. 23.		
	*7. Klobat at Kema in the N.E. part of Celebes,	1. 29.	125. 18.	1680	
	? ? 8. V. of Banca I.,	1. 44.	125. 07.		
	? ? 9. V. of Bejaren I.,	2. 06.	125. 18.		
	? ? 10. V. of Tagolanda I.,	2. 23.	125. 15.		
	*11. V. of Siao I.,	2. 43.	125. 29.		
	*12. Abu in the northern part of the Sanguir I.,	3. 40.	125. 37.	1711	
	*13. Sanguill, in the district Serangani (Vs. of Mindanao I.,)	5. 44.	125. 18.	1764	
	*14. Kalagan, NW. of C. San Augustin	6. 34.	125. 46.		
	*15. Illano or Sanall, near the Lake Lano	7. 28.	124. 24.	1640	
	*16. V. of the I. Fuego or Siquijor,	9. 05.	123. 28.		
	? *17. Bulusan (Volcanoes of the Penins. of Camarines, Volcanoes of the Island of Luzon,)	12. 47.	124. 07. 47		
	*18. Albay or Mabon	13. 23.	123. 47. 55	1814	
	? *19. Mamaija	13. 21. 50	123. 43.		
	? *20. Buji	13. 33. 30	123. 40.		
	? *21. Yriga,	13. 34.	123. 31. 50		
	*22. Ysarog	13. 37.	123. 31. 45		
	? *23. Colasi	13. 50. 30	123. 12.		
	? *24. Lobo	14. 10. 05	122. 52. 35		
	? *25. Banaoay	14. 18. 20	122. 52. 10		
	? *26. Bonotan	14. 27. 35	122. 44. 30		
	*27. Bonajan de Tayabas,	14. 03.	121. 42.		
	*28. Taal in the Lake Tale,	14. 00.	121. 03.	1754	
	? ? 29. Aringuay or Aruagay—(perhaps Monte de San Tomas)	16. 12.	120. 40.	1641	
	? ? 30. Arayat,	15. 13.	120. 45.		
	*31. V. of I. Arabil, W. of Luzon,	13. 45.	120. 22.	1641	
	32. V. of Camiguin I.	18. 54.	121. 52. 40		
	*33. V. of Claro Babuyan I.,	19. 27.	122. 02. 15	1833	
	*34. Tale-kang (or Red Mountain), (Vs. of I. Formosa,)	22. 29.	120. 53.		
	? ? 35. Phy-nan [illegible]	22. 27.	120. 44.		
	*36. Ho-shan (or Fire Mount.),	23. 19.	120. 44.		
	*37. Lieu-hoang shan (or Brimstone Mount.),				
VIII. Japan,	*1. Lung-hoan shan or Sulphur [illegible] Archipelago of Loo-choo,	27. 50.	127. 45.		
	? ? 2. V. of the I. of Tanega [illegible]	28. 20.	130. 40.		
	*3. V. of Jewo sima or [illegible]	30. 43.	130. 16. 23		
	*4. Asama yama, in the [illegible] Figo, (Vs. of the I. of Kiusiu,)				
	*5. Un sen ga dake, [illegible]			1793	
	*6. Biwo no kubi,			1793	
	*7. Mayi yama,			1793	
	*8. V. near the I. of Fi[illegible] of Kiusiu,				
	*9. Fusi no yama, in the [illegible]	34. 50.	139. 02.	1707	? 12,000
	*10. V. of the I. Oo sima [illegible]	34. 40.	139. 32.	1797	
	*11. V. of the I. Naki sima,	31. 01. 20	130. 34.		
	*12. Sira yama (or White M[illegible] (Vs. of the I. of Niphon,)				
	*13. Asama yama or Asama [illegible]	36. 12.	138. 32.	1783	
	? *14. Peak Tilesius,	49. 37.	140. 18.		
	*15. Tsan,	40. 02.	142. 08.		

SYSTEMS.	VOLCANIC SERIES—continued.	Geographical Position.		Date of last Eruption.	Height in Eng. feet.
		Latitude.	Longitude.		
VIII. Japan—continued.	*16. Yake yama, in the prov. Mutu, Vs. of the I. of Niphon,	41. 16. N.	141. 12. E.		
	*17. V. of Koo sima I.,	41. 21. 30	139. 46.		
	? ? 18. V. of Oo sima I.,	41. 31. 30	139. 19.		
	*19. Utchi ura yama,	41. 50.	141. 10.		742
	*20. Oo sna yama, (Vs. of the I. of Yesso,)	42. 00.	140. 50.		
	*21. Usu ga dake,	42. 27.	141. 08.		
	*22. Yuuberi or Ghinsan,	42. 45.	161. 20.		
	? ? 23. Peak Langle	45. 11.			
IX. Kurile Isles,	? ? 1. Anton's Peak or Tchatchanaburi in the I. of Kunashir,	44. 31.	145. 46.		5,300
	? ? 2. V. of the I. of Tchikotan or Spanberg's I.,	43. 53.	144. 43.		
	*3. V. of the I. Iturup,	45. 30.	149. 00.		
	4. V. of South Tchirpo oi I.,	46. 29. 15	150. 33.		
	? ? 5. V. of Sivutchei or Broughton's I.,	46. 42. 30	150. 28.		
	6. Itaikhoi of Schimuchir I.,	47. 02. 50	151. 52. 35		
	? *7. V. of I. Uchichir,	47. 32. 40	152. 28. 15		
	*8. Pk. Sarujitcheff in the I. of Matua or Mutova,	48. 06. 00	153. 12.		
	*9. V. of Raukoko or Rachkoke,	48. 16. 20	153. 15.		
	? *10. Sinarka of the I. of Schiaschkotan,	48. 55.	154. 08.		
	*11. V. of Ikarma I.,	49. 00.	154. 08.		
	*12. V. of Kharamokatan I.,	49. 08.	154. 39.		
	*13. To orussyr, (Vs. in the I. of Onekotan or Anakutan,)	49. 24.	154. 46.		
	14. Amka-ussyr,	49. 32.	154. 58.		
	*15. Asirmintar,	49. 40.	155. 03.		
	16. V. in the northern part (of the I. Porommushir,)	50. 40.	156. 05.		
	*17. V. in the south-western part	50. 15.	155. 24.	1793	
	*18. V. of Alaid I.,	50. 54.	155. 32.	1793	
X. Kamtchatka,	*1. (Two Kurilian Volcanoes,)	51. 44.	156. 51.		
	*2.	51. 53.	156. 50.		
	*3. First or Opalinskaja Sopka, or Kochaleff,	51. 30.	157. 16.		
	*4. Gijapenkitch or Hodutka	51. 48.	157. 29.		
	*5. Assatchinskaja Sopka,	52. 02.	157. 43.		
	*6. First Wiliutchinskaja S. or Poworotnoi, also Flat Mt.,	52. 23. 30	158. 19.	1828	
	*7. Opalnaja S.,	52. 30.	157. 30.		7,920
	*8. Second Wiliutchinskaja S.,	52. 41. 30	158. 17.		
	*9. Koselskaja S.,	53. 13. 30	158. 58.		6,746
	*10. Awatchinskaja or Gorelaja S.,	53. 15.	158. 50.	1827	9,055
	*11. Koriazkaja or Strelochnaja S.,	53. 19.	158. 44.		11,220
	*12. Schupanowa S.,	53. 32. 30	159. 18.		
	*13. Kronozkaja S.,	54. 48.	160. 24.		10,608
	? *14. Chichapinskaja S.,	55. 11. 30	159. 58.		
	*15. Tolbatchinskaja S.,	55. 51. 26	160. 00. 06	1739	8,300
	*16. Fourth S.,	55. 58. 30	160. 27.		
	*17. Uchinskaja S.,	56. 00. 30	160. 17.		11,721
	*18. Krestowskaja S.,	56. 04. 00	160. 24. 30		9,592
	*19. Klutchewskaja, or Kamtchatskaja S.,	56. 04. 18	160. 30. 48	1829	15,763
	*20. Schiwelutsch, south-western summit,	56. 39. 33	161. 13. 52		8,753
	*21. Schiwelutsch, north-eastern summit,	56. 40. 32	161. 16. 27		10,548
XI. Mariana Is.,	1. Ilikiu in the I. of Guam or Guahan,	13. 24.	144. 47.		
	? ? 2. V. of Tinian I.,	15. 02.	145. 43.		
	? ? 3. V. of Isle of Birds, or Farallon de Medenilla,	15. 58.	146. 18.		
	*4. V. of Guguan I.,	18. 06.	146. 16. 30		
	*5. V. of Pagon I.,	18. 45. 45	145. 45.		
	6. V. of Grigan I.,	19. 18.	145. 52.		
	*7. V. of Assuncion, Assomption, or Volcan Grande,	19. 40.	145. 27.		2,094
XII. Bonin Sima Isles,	? *1. V. of Los Volcanos Islands (Brimstone I.),	24. 48.	141. 13.		
	? *2. V. of Peel I.,	27. 05.	142. 16.		
	B. NEW WORLD.				
XIII. Aleutian Isles,	*1. V. of Little or West-Sitkhin I.,	51. 57.	179. 20.		
	*2. V. of Ostrowa Semisopotchni I.,	51. 59.	179. 46.		? 3,000
	*3. V. of Ostrowa Gorell I.,	51. 47.	178. 40. W.		
	4. V. of Tanjaga I.,	51. 55.	178. 10.		
	*5. V. of Kanjaga I.,	52. 01.			
	6. V. of East-Sitkhin,	52. 04.	176. 02.		5,030
	7. V. of Kasatotchy I.,	52. 09.	175. 17.		
	*8. V. of Konjuschi I.,	52. 15. 48	174. 57.		
	*9. Klintchewskaja, (Volcanoes of the I. of Atkha,)	52. 20.	174. 00. 20		
	*10. Korovinskaja,	52. 23. 42	174. 01. 18		
	*11. V. of the NE. point				4,852
	*12. V. of Siguam I.,	52. 22.	172. 18.		
	13. V. of Amukhta or Amakhta I.,	52. 26.	171. 04.		
	*14. V. of Yunaska I.,	52. 40.	170. 08.	1830	
	15. Tchegulak,				
	16. Uliaghin,				
	*17. V. of Tanakh-Angunakh I.,				
	*18. Kigamiliakh,				
	*19. Wsewidowskoi (Volcanoes of Umnak I.,)	53. 15.	168. 05.		
	*20. Tulikskoi	53. 20.	167. 55.		
	*21. V. of Joanna Bogoslowa I. or Agachagakh,	53. 56. 20	167. 58. 35	1823	1,082
	*22. Makuchinskaja, in the I. of Unalaschka,	53. 52.	166. 45.		5,474
	*23. V. of Akutan I.,	54. 10.	165. 52.		3,332
	*24. V. of Akun I.,	54. 17.	165. 22.		
	*25. Schischaldinskoi (This & 4 others in Unimak,)	54. 45.	163. 59.	1825	8,952
	*26. Pogromnoi or Nossowskoi,				6,500
	31. V. of St George I., (one of the Pribuiloff Is.),	56. 38.	166. 10.		
	32. V. of Aanak I.,	55. 25.	163. 01. 45		
	*33. Morchewskoi (Vs. of the Peninsula Aliaska,)		163. 00.		
	*34. Pawlowskoi		162. 40.		
	*35. Medwadnikowskoi		162. 30.		
XIV. North American Series,	*1. Iliamin (Vs. W. of Cook's Inlet,)	60. 00.	152. 30.		12,066
	? ? 2. V. opposite the Redoute St Nicolaus	60. 40.	152. 58.		11,270
	*3. Wrangell's V. at the River Atna,	61. 05.	143. 20.		
	? ? 4. Mt. Elias,	60. 17. 30	140. 51. 20		17,854
	? ? 5. Buen Tempo,	58. 50.	136. 06.		14,900
	6. Edgecumbe or Jacinto in the I. of St Lazarus,	57. 01. 30	135. 30.	1796	3,000
	*7. St Helens (Vs. near the River Columbia,)	45. 37. 46	117. 33. 11		
	? *8. V. E. of St Helens	46. 00.	115. 50.		
	9. Virgenes (Vs. of California,)	28. 00.	113. 40.	1746	
	? ? 10. Giganta	26. 05.	111. 22.		4,800
XV. Mexico,	*1. Colima,	19. 25.	103. 54.	1795	12,000
	*2. Jorullo,	19. 10.	101. 01. 45		4,265
	3. Toluca,	19. 11. 30	99. 25. 40		15,162
	*4. Popocatepetl (= Smoking Mt.) or V. Grande de Mexico,	18. 59. 47	98. 33. 15		17,717
	5. Istaccihuatl (= White Women),	19. 10.	98. 35.		15,705
	*6. Orizaba or Citlaltepetl,	19. 02. 15	97. 15. 15	1566	17,374
	*7. Tuxtla,	18. 30.	94. 50.	1793	
XVI. Guatemala,	1. Soconusco,	15. 52. 30	93. 47. 40		
	*2. Vs. de las Amilpas or Hamilpas, Western Pk.,	15. 09. 54	92. 03. 55		13,100
	*3. Eastern Pk.,	15. 04. 50	91. 51. 20		13,050
	4. Sapotitlan,	14. 55.	91. 47.		
	5. Tajamulco or Quesaltenango,	14. 46. 30	91. 46.		
	*6. Atitlan,	14. 47.	91. 28.		12,500
	? ? 7. Toliman,	14. 42.	91. 27.		
	? ? 8. Acatenango,	14. 38.	91. 21.		
	*9. Fuego,	14. 30.	91. 08.		
	*10. Agua,	14. 33. 30	91. 04. 40		14,000
	*11. Pacaya,	14. 15.	90. 28.		
	? *12. Panoca,	13. 49. 30	89. 44.		
	*13. Isalco, Sonsonate or Trinidad,	13. 48.	89. 35.	1825	1,500
	*14. San Salvador,	13. 50.	89. 05.		
	*15. Sacate coluca or St Vincent,	13. 33. 40	88. 40.		
	*16. San Miguel Bosotlan,	13. 26.	88. 09. 37		
	17. Guanacaure,	13. 28.	87. 02.		3,806
	*18. Cosiguina or Coseguina,	13. 05. 20	87. 29. 20	1835	1,000
	19. Jolotepec or Gilopete,	13. 00.	87. 12.		
	*20. Viejo,	12. 40.	86. 53.		9,600
	*21. Telica,	12. 28.	86. 46.		
	22. Asososca,	12. 35.	86. 40.		
	*23. Momotombo or V. de Leon,	12. 27.	86. 36.		
	? *24. Masaya,	12. 03.	86. 14.		
	*25. Mombacho,	11. 56.	86. 03.		
	*26. V. of the Isla Ometepe in the Lake Nicaragua,	11. 40.	85. 40.		
	27. Orosco or Popayao,	11. 20.	85. 32.		9,574
	28. Rincon de la Vieja or Zapateras,	11. 15.	85. 20.		
	*29. Miraballes,	11. 10.	85. 07.		
	30. Tenorio,	11. 11. 50	84. 54. 30		
	31. Seropelos or Cerro Pelos,	11. 14. 50	84. 49. 30		
	32. Ahogadas,	11. 11. 50	84. 37.		
	*33. Votos,	10. 00.	84. 10.		8,848
	*34. Erradura,	9. 25.	84. 17.		
	*35. Barba,	9. 28.	84. 03.		
	*36. Chirripo,	9. 48.	83. 47.		
	*37. Turrialva,	9. 44.	83. 43.		
	*38. Irasu or V. de Cartago,	9. 25.	83. 51.		11,478
XVII. Antilles,	1. The Punchbowl of I. St Eustatius,	17. 29.	63. 01.		2,730
	? *2. Mt. Misery of I. St Christopher or St Kitts,	17. 18.	62. 53.		
	*3. V. of I. Nevis,	17. 14.	62. 41.		
	*4. V. of I. Montserrat,	16. 47.	62. 18.		
	*5. Souffriere of I. Guadeloupe,	16. 15.	61. 47.	1797	5,136
	*6. Morne Diablotin or Terre Firme of I. Dominica,	15. 25.	61. 27.		6,023
	7. Pelée of I. Martinique; (also Piton du Carbet, extinct V.),	14. 45.	61. 15.		4,430
	*8. V. of St Lucie,	13. 15.	61. 00.	1766	1,920
	*9. Morne Garou of I. St Vincent,	13. 00.	61. 10.	1812	3,097
	10. Morne Rouge of I. Grenada,	12. 15.	61. 44.		840
XVIII. Quito,	*1. Tolima,	4. 46.	75. 37.		18,020
	2. Purace, E. of Popayan,	2. 20.	76. 20.		17,035
	3. Sotara, SE. of Popayan,	2. 13.	76. 18.		
	*4. V. at Rio Fraga,	2. 10.	75. 20.		
	*5. Pasto or Tuqueres,	1. 13.	77. 20.		13,453
	*6. Azufral,	1. 02.			15,630
	*7. Cumbal,	0. 48.	78. 07.		
	8. Chiles,	0. 36.	78. 00.		
	9. Imbabura,	0. 00.	78. 18.		
	*10. Pichincha,	0. 12. S.	78. 50. 30	1831	15,924
	*11. Antisana,	0. 29. 45	78. 24. 30		19,137
	12. Guachamayo,				16,434
	13. Sinchulagua,	0. 35.	78. 30.		19,875
	*14. Cotopaxi,	0. 41.	78. 42.	1803	18,873
	15. Carguairazo,	1. 23.	79. 04.		16,424
	*16. Tunguragua,	1. 30.	78. 41.	1797	16,158
	*17. Sangay or Macas,	2. 00.	78. 33.		
XIX. Peru and Bolivia.	*1. Chacani or Guagua-Putina,			1830	20,720
	*2. Volcano de Arequipa,	16. 19.	71. 42.		
	*3. Pichu-Pichu,				16,000
	4. Ubinas or Ubillas,	16. 20.	? 71. 16.	1667	
	*5. Omate,	16. 50.			20,500
	6. Viejo,	16. 55.			18,745
	*7. Chipicani,	17. 50.	69. 53.		
	*8. Chungara,	19. 10.	? 69. 20.		
	*9. Agua,	? 19. 30.	? 69. 40.		
	? ? 10. Isluga,	19. 48.	68. 40.		22,000
	*11. Gualatieri or Sehama,	20. 13.	69. 17.		
	*12. Atacama,	? 22. 00.	? 68. 28.		
XX. Chili.	? ? 1. Limari,	31. 6.	70. 10.		
	? ? 2. Chuapa,	31. 21.	70. 12.		
	? ? 3. Ligua,	31. 57.	70. 14.		23,910
	? ? 4. Aconcagua,	32. 39. 30	70. 00. 30	1835	15,100
	? *5. V. of Tupungato, Santiago (or Penquenes?),	33. 20.	69. 54.		
	*6. Maypu,	33. 46.	70. 00.		
	*7. Rancagua,	34. 16.	70. 06.	1822	
	*8. Peteroa (or Azufre?),	34. 50.	70. 06.		
	*9. Chillan, Descabezado or Longavi,	36. 05.	70. 10.		8,513
	*10. Antuco,	36. 58.	70. 50.	1820	
	*11. Punmahuida or Peinahuida (Vs. E. of the Andes)	36. 15.	67. 40.		
	*12. Unalavquen	37. 10.	? 67. 00.		
	*13. Cura, Callaqui or Mulliquieo,	38. 10.	70. 20.		
	? ? 14. Chinal,	38. 47.	70. 48.	1640	
	*15. Villarica,	39. 10.	71. 10.		
	? *16. Chinal,	39. 54.	71. 38.		
	? *17. Ranco,	40. 20.	71. 52.		7,550
	*18. Osorno,	41. 09. 30	73. 36. 45		
	? *19. Quechucahi,	41. 10.			8,600
	*20. Minchinmadiva,	42. 48. 00	72. 34. 30		7,510
	*21. Corcobado,	43. 11. 20	72. 48. 40		6,926
	*22. Yantelos,	43. 30. 00	72. 50. 30		6,810
XXI. Tierra del Fuego.	1. Sarmiento,	54. 27. 15	70. 51. 15		4,000
	2. Buckland,	54. 26. 00	70. 22. 30		
	? ? 3. Clement,	? 54. 46. 05	62. 03.		400
XXII. Supposed Antarctic S.	*1. Bridgman, in the South Shetland Is.,	62. 44.	163. 11. W.		
	*2. V. of Buckle I., (Balleny Is.),	61. 20.	66. 39. E.		
	*3. Erebus, in South Victoria,	77. 32. 00	167. 0. 0		12,400

PLATE II

COMPARATIVE VIEWS OF REMARKABLE
GEOLOGICAL PHÆNOMENA.

A SERIES OF

DETAILED MAPS, PLANS, SECTIONS, AND VIEWS OF VOLCANIC AND OTHER INTERESTING GEOLOGICAL FORMATIONS.

INTRODUCTORY NOTE.

"It appears to me," says A. von Humboldt, "of the greatest advantage to geology to be enabled to compare the forms of mountains in the most distant parts of the globe, in the same manner as we are accustomed to compare the forms of vegetables under different climates."[1] The selections presented in the accompanying map have been made in accordance with these views of the illustrious philosopher. In the Map of the Phænomena of Volcanic Action (Plate 10, page 37), we have given a general outline of the geographical distribution of volcanic forces over the globe; and the present sheet, which may be considered as an appendage to the former, presents, on an enlarged scale, detailed views of the peculiar form and extent of some of the best known volcanic and other geological formations.

Such representations, when accurately delineated, are of the utmost value in conveying precise ideas, not only of the geological structure, but also of the physical formation of the countries in which they occur; and in preparing new drawings of the different subjects, adapted to the plan of the Physical Atlas, we have anxiously endeavoured to convey the full effect, while preserving the minutest detail of the originals.

These interesting tableaux, for several of which we are indebted to the laborious researches of the most distinguished naturalists, having been selected for the purpose of affording comparative views, it would have been desirable, had this been compatible with distinctness of detail, to have constructed them all to the same scale; but as this was not possible in our limited space, we have endeavoured, by preserving an exact relative proportion between the several scales employed, to render a comparative estimate of surface extent easy and expeditious.

Thus, in the upper division of the sheet, the Map of Teneriffe is drawn to a scale of 1-550,000 (about nine miles to one inch); the middle compartment, containing South Keeling Island, Pichincha, Antisana, and the Island of Ascension, 1-200,000 (about three miles to one inch); and the lower division, containing the crater of Gedee, Graham Island, and Arthur's Seat (as well as the craters of Vesuvius and Etna on the upper compartment), 1-20,000 (about three inches to one mile). The three scales, therefore, bear to each other the proportions of 1, 10, 30.

All the subjects have a direct reference to volcanic phænomena, except South Keeling Island and Arthur's Seat; the former of which was introduced to show the contrast between the coralline and the volcanic formations; and the latter, which was surveyed expressly for this work, as affording a ready means of comparison between known and unknown objects. Thus while the low reefs of the lagoon-atolls scarcely rise above the waves of the surrounding ocean, the volcano of Pichincha towers to the height of nearly 16,000 feet, although the former occupies fully as much horizontal surface as the latter. A similar comparison shows the vast extent of the crater of Gedee as compared with the craters of Vesuvius and Etna; and the relative size of each may be realized by comparison with the outlines of the different formations of Arthur's Seat. From these general remarks we proceed to a brief description of the several objects delineated, referring for full information to the writings of the respective authors.

PHYSICAL MAP OF THE ISLAND OF TENERIFFE.

Teneriffe, the largest and most important of the Canary Islands, extending between latitude 28° and 28° 37′ north, and longitude 16° 8′ and 16° 57′ west, is about 60 miles in length, and from 5 to 30 miles in breadth. The position of the British consul's house in Santa Cruz is latitude 28° 28′ 4″ north, longitude 16° 14′ 7″ east; and the Peak of Teneriffe, or the Pico de Teyde, latitude 28° 17′ north, longitude 16° 40′ west.[2] In describing the chief physical features of the island, we shall follow the arrangement adopted by its illustrious explorer, referring to the original work[3] for the most ample details.

Circus of the Peak.—The Peak is surrounded by a girdle, which gives it the appearance of a fortified tower, encircled by its fosse and bastion. It is distinctly seen on ascending to the foot of the *Piton*, by the strait passage *El Portillo*. Thence the rocks appear to form a sort of semicircle, which surrounds, with remarkable regularity, the volcanic cone. This is the circus, from which point alone the prodigious elevation of the Peak can be judged of, for here it is seen in all its parts, from its most elevated ridge to the most minute particulars presented by the slopes of the cone. Streams of black obsidian descend on the flanks of the mountain, covered with white pumice, and the volcanic mouths of the *Estancia abazo*, *Estancia ariba*, and *Altavista*, which appear to be points whence so many currents of obsidian have flowed, form as it were the steps of the cone, and, by dividing its height, afford a sort of scale by which to estimate the immense elevation of its summit.

Adexe is situated at a height of 984 feet above the level of the sea, to the south-west of the Peak, in a place where the flank of the mountain is hollowed by a deep ravine, in the middle of which flows a considerable rivulet—a rare circumstance in the island. This valley, bounded on each side by perpendicular rocks, and called *Baranco del Infierno*,[4] is a fissure opened in the interior of the mountain, which penetrates even to the circus. The crater of elevation is formed in the trachyte, and has thrown out over its sides the basaltic beds which are formed on its upper parts. The immense cone of the Peak which rises in the middle of the crater, and all the substances which have been ejected from it, present in all directions no other rock: hence this volcano is essentially trachyte, like the greater number of those which have been studied with care.

Base of the Peak to the north and north-west. From the point where the perpendicular rocks forming the circus terminate, above Adexe, the whole flank of the mountain of the Peak is covered by volcanic lava, which constitutes such immense masses as to extend, in small black streams over a space of many leagues. The villages of Guia, Chio, and Arguajo, are built of these lava stones. The baranco of *Juan Lopez* is separated into two parts by a mountain 2,453 feet high, in which is the narrow defile of *Corrizal*, excavated in the immense cape of Teno, the north-west point of the island. The wide Valley of *S. Jago* communicates with that of El Palmar[5] in the middle of which there are two very remarkable volcanic cones, which occupy its entire breadth. The stream of lava which these cones have ejected flows towards *Buenavista*, and is composed of masses having the form of great scales, between which are numerous cavities. South of *Garachico*, between two mountains, is seen the lava stream which, in 1705, destroyed this town, and filled up the best, or rather the only, port of Teneriffe. The lava flowed from several volcanic cones, elevated more than 1,065 feet above the level of the sea. Immense sterile blocks piled one upon another, like moraine upon a glacier, cover the surface of the lava. The greatest stream, and that which divided the narrow port of Garachico into two parts, advances far into the sea.

The Mountain of *Chahorra* is united to the Peak at its base, and is only separated from it in its higher regions. All the currents of lava have flowed immediately from parts of the base common to both; and of all the streams which extend to Icod, there is hardly one whose origin is situated below the base of the Peak: they have thus in great part flowed from a height of more than 9,592 feet, and are spread over a space of a league and a half. The appearance of these lava streams must necessarily have preceded all tradition; for it is very improbable that, during the catastrophe which produced these masses, sufficient to cover a space of more than a mile square, the island could have continued habitable.

The Peak is properly a mountain which rises upon another mountain. On entering the circus by the defile of Portillo, the explorer has only arrived at the foot of this new mountain; that is to say, at the parts which are proper to it, and by which it is distinguished from the protuberances which precede it; all of which, however high, can only be considered as an exterior envelope which does not essentially belong to the Peak. From Portillo, the flanks of the cone present such a mass of pumice-stone, that the whole mountain appears at a distance as if entirely covered with snow. Currents of obsidian detach themselves on the pumice, like broad black ribbons depending from the summit. Some of these extend to the bottom of the circus; others, arrested at mid height, remain suspended on the flank of the cone; others, again, extend to so little distance that they can only be distinguished on the summit of the Peak by their black colour, which contrasts so strongly with the white surface on which they repose. This porous surface cannot sustain either trees or grass; the only bushes which can vegetate on its arid and dry soil, are *Spartium nubigenum* and *Retama blancos;* the roots of which extend to a considerable distance across the crevices on the surface. A few hundred feet above the base of the Peak is the *Monte Trigo*, or mountain of wheat; so called because the pieces of pumice-stone roll upon each other along the slopes of the mountain like immense grains of corn, and because this part of the cone appears as if entirely covered with such grains.

Above Monte Trigo is *l'Estancia abazo*, a small plain, where travellers who ascend the Peak usually pass the night. This place is 8,568 feet above the level of the sea, and more than 2,130 feet above Portillo. Beyond this plain, the flank of the mountain rises rapidly along a current of obsidian: the route follows a serpentine course, and the pumice-stones are larger. For half-an-hour the road follows the current of obsidian to *Altavista*, where the traveller is obliged to quit the pumice-stone to mount on the obsidian itself; it is then with great pain and difficulty that one can guide himself across the sharp blocks—the vitreous nature and cutting angles of which render them as dangerous as the blades of a knife. It requires more than half-an-hour to traverse this field of glass, and it is certainly not without reason that this part of the route has received the name of the *Malpays*.

In the middle of the field of obsidian, the blocks piled over one another have formed a deep grotto, the bottom of which is constantly covered with ice. This grotto, called *Cueva del Hielo*, is very valuable on account of the ice, of which it yields a constant supply to the localities at the foot of the mountain.

Beyond the Malpays rises the last cone, *the Piton*, or *sugar loaf*, which is singularly abrupt, and everywhere covered with white pumice. The height of the Piton is not more than 852 feet: but the small particles of pumice which cover its surface have so little consistency that it is ascended with great difficulty. The most elevated point of the crater is that towards the north-east, and the lowest on the south-west. From this point the crater sinks very little to its centre; the difference of level between these two points being at most 21 feet. From all sides, except some points on the west which present abrupt rocks, there is an easy descent to the interior of the crater, which is nothing more than a *solfatara*, from which sulphureous vapours are disengaged at almost all parts. Its entire circumference is at least half a league; its depth from the most elevated point is 170 feet, but below the greater part of its sides it is not more than 106 feet. The interior does not present any trace of other small craters, nor is there any scoriæ. It appears, indeed, for ages to have been only a solfatara. From the rocks on the western side, a new crater is seen to open up beneath the feet of the spectator, larger than that which forms the summit of the Peak; this is the immense crater of *Chahorra*. This latter mountain was unknown to naturalists till 1803, when it was discovered by M. Cordier, who thinks, since its crater, and the streams of lava which have issued from it, so far surpass those of the Peak, that it should be considered as the principal mouth of the volcano. The height of the *Pico de Teyde* is 12,182 feet; hence the height of the cone above the surface of the pumice-stone of Chahorra is 2,345 feet. The crater of Chahorra is of no great depth—perhaps not more than 149 feet. The most elevated point of this mountain, the southern border of the crater, which is 9,886 feet above the level of the sea, is covered with pumice. At the foot of the Mountain of Chahorra, on the west side, rise four other volcanic cones, which, on the 17th June 1798, reminded the inhabitants of Teneriffe that they dwelt at the foot of a volcano. These cones are all disposed on a line directed from the base of Chahorra towards the rocks of the circus; thus indicating the direction of the line of fracture. From the third of these cones a stream of lava reached the circus; but the wall of rock prevented its farther descent, so that the fear of the inhabitants of Guia, Chio, and Arguajo, that the lava would reach and destroy their plantations, was unfounded. The two volcanoes of Chahorra form only one immense dome of trachyte, enveloped on almost all sides, as by a mantle, with beds of basalt. The form and position of these cones suggest the idea—and this hypothesis is almost a certainty—that they have been produced by the raising of a mass urged by internal pressure to the surface, and which, in forcing for itself a passage through the middle of the crater of elevation, caused the superior mass to assume the form of a vault.

Guimar, situated on the south-east part of the island, is separated from *Orotava* by the Mountains of the *Cumbre*, from the summit of which is seen the volcano of Guimar, a great eruptive cone, 2,282 feet high, whence a stream of lava descends. This current is divided into three branches, each of which corresponds with a particular opening in the flank of the mountain; but these openings have all been produced during the same eruption; and this—the only one which has occurred in this part of the country—commenced, according to Viera, on the 31st December 1704. On the 2d February the lava reached Guimar, and destroyed the church.

From the time of the conquest of the island, towards the end of the fifteenth century, there has been no eruption of Teneriffe, at least no document has been discovered mentioning such an event. This eruption was therefore the first during many centuries; which is the more remarkable, since this renewal of activity in the volcano was not limited to the country around Guimar, but immediately manifested itself also on the other side of the principal crater. The eruption which destroyed *Garachico* occurred on the 5th May 1706, by a crater which is situated so exactly opposite the volcano of Guimar, that a line joining the two would pass through the cone of the Peak, and at a little distance from the summit. The eruption which followed occurred on the 17th June 1798. Nearly a century had elapsed between the two, but this last occurred on the upper flank of the Peak. Hence it appears evident that the eruptions are connected with the great crater of the Peak, which forms the principal communication between the interior of the globe and the external atmosphere, and that they are not owing to independent volcanic sources. It results from this that, properly speaking, there is only one volcano on the island, and that is the trachytic dome which bears the name of the Pico de Teyde.

VOLCANOES OF PICHINCHA AND ANTISANA.

These important volcanoes, for the representation of which we are indebted to the surveys of A. von Humboldt, are situated on the Andes of Quito, where the chain reaches its greatest elevation, in the republic of Ecuador. The Andean chain here forms a double ridge of colossal summits, enclosing between them the elevated Plateau of Quito, the highest inhabited region of the globe, which extends from 25 to 30 miles in breadth, at an elevation of from 9,000 to 9,500 feet above the level of the sea. Pichincha is situated on the western chain, in latitude 0° 12′ south, longitude 78° 50′ 30″ west; and Antisana on the eastern ridge, in latitude 0° 29′ 45″ south, longitude 78° 24′ 30″ west. The elevation of the principal points on this part of the Andes are, Antisana, 19,137[6] feet; Rucu-Pichincha, 15,922 feet; the town of Quito, 9,541 feet; the country seat of Chillo, near the plain of Gachapamba, 8,575 feet; and that of Pintac, to the south-east of the former, 10,142 feet.

Humboldt considers it very probable that the greater part of the high region of Quito, as well as the neighbouring mountains, is formed of an immense volcanic dome, which, extending from north to south, embraces a space of more than 600 square miles. Cotopaxi, Tunguragua, Antisana, and Pichincha, are elevated above this vault like the different summits of the same mountain. The masses of inflamed substances escape sometimes by the one, and sometimes by the other of these volcanoes; and when the obstruction of one of the craters would lead to the belief that the volcano is extinct, it often happens that the volcanic action is exercised with undiminished intensity in the interior, and in its vicinity below Quito, as well as below the volcanoes of Imbabura and Pichincha.[7] This volcanic vault, at which a new series of volcanoes commences, is separated from those of Peru by a space of 14 degrees of latitude; which space is occupied by the chain of the Andes, among the highest mountains on the surface of the globe. We know nothing of the nature and composition of the northern part of this chain, except through the researches of A. von Humboldt, and from some observations in the voyages of M. de Helm. The little we do know, however, is sufficient to show how much its character differs from that part which is absolutely free from volcanic action.[8]

Antisana was in a state of activity in the year 1590, since which time it does not appear to have made any considerable eruption[9] although Humboldt saw smoke issuing from several openings in March 1802; and it is the only one of the volcanoes of Quito on which he observed, near the summit, something analogous to a current of lava. This current was similar to obsidian. On the slope of the mountain there was also noticed pumice-stone and scoriæ, having the appearance of pitchstone.[10]

Pichincha. There are two mountains of this name—Rucu (the old), and Guagua (the young), Pichincha.[11] The first, the eastmost of the three rocks which border the crater, is the only volcano on the western chain of whose activity Europeans have had evidence since their acquaintance with this region.[12] It has an immense crater, 4,790 feet in diameter. The first known eruption of this volcano, which preceded a great earthquake in Quito and its vicinity, occurred in 1538. It was again active in 1577 and in 1660.

PLAN OF THE CRATER OF VESUVIUS.

At the time when I was occupied in preparing this map, says M. Abich,[13] the crater of Vesuvius was accessible at all points, and at the most interesting period of a complete development.

It appeared to me desirable to execute the plan of the crater in this state, which permitted me to unite on a single map a series of important phænomena which succeeded each other without interruption, so that it might serve as a chronological description of everything remarkable that has occurred in the crater of Vesuvius since the last period of its activity. The map represents nearly the upper third part of the great cone of Vesuvius. It shows the currents of lava which, during the years 1833 and 1834, overflowed the borders of the crater on the east and west. They are very numerous and of different widths, placed one over the other, and furrowing the slopes of the mountain; whilst the northern border from Punta dell'Eremo to that of Mauro, and the border from Punta della Torre to that of Bosco, opposed natural walls or counterforts to the progress of the currents. These walls, the mutual relations of which are indicated on the section, differ in height. Those on the north rise to about 295 feet, and those on the south to only 98 feet, above the level of the plain of lava (marked A on the plan). This plain is slightly upheaved at the centre, whence rises, in the form of a sugar loaf, the cone of ashes which, properly speaking, terminates the crater of Vesuvius.

The mode of formation of this plain is thus explained. The crater of Vesuvius had a depth of 426 feet, when, in the month of March 1827, the volcano gave the first indication of renewed activity. Then the volcanic substances, accumulated in the depths of the mountain, during an absolute repose of six years, impelled by the elastic fluids, opened a vent by different crevices, which traversed the surface of the crater; and currents of lava, accumulating one upon another, successively filled up its enormous cavity. For a considerable time the volcanic mouths changed their position upon the continually tormented surface. They formed themselves, however, constantly above a great fracture, directed from the south-west to the north-east, and which the mass of matter, incessantly deposited above it, could not obliterate. These different openings ended by all uniting, and forming, so to speak, a single centre of eruption, within the circle of which arose the actual cone of ashes, by the successive accumulation of ejected substances always disposing themselves around the same orifices. The form of the crater of the cone represented on the plan is that of a funnel of about 82 feet deep, at the lowermost part of which are seen two openings half filled, the alternate activity of which, doubtless, gives to the crater its elliptic form.

The eruptions of lava streams, properly so called, those which flow continuously and during determinate periods, occurred only at the base of the cone of ashes, and with very few exceptions, in the direction of the crevice noticed above. The principal effect of the activity of which this crevice was the seat, was an upheaval in the form of a dike (*e e* on the plan), which was produced at the base of the cone, and which tended to unite this with the edge of the great crater. This has been designated the promontory of the cone of ashes. At the commencement of its formation, this dike sunk insensibly, and was confounded with the plateau; but immediately, almost at the western base, it was traversed by a great fissure, which opened in the direction north-east to south-west, and, by an angular turn, continued in the direction of north-west. Then all the eastern part was upheaved about 21 feet above the plateau, and presented, in the part opposite the other side of the cleft, a sort of steep beach, as if cut with the pick-axe, and the fracture of which allowed the beds of lava, elevated at the same time on that part of the ground, to be very easily distinguished. Shortly after, new liquid substances sought to open a passage for themselves in this place, and, by a very peculiar effect of this phenomenon, the opposite side of the cleft which remained stationary, gave birth to a series of little cones of eruption, which followed the contours of the bottom of the cleft, to their junction with the sides of the great crater. These little cones were formed in two distinct groups. The first group (*f*) followed the whole north-east side of the cleft; and when its activity was diminished, the second (*i*) appeared on the north-west side. The greater part of the lava escaped from the base of small cones, by openings (*k*) in the scorified and indurated surface, in a manner similar to that of water overflowing the gaps in the ice which covers a river. The letter (*d*) indicates an upheaval of the soil, in the form of an elliptic dome, traversed by considerable fissures, all placed against the western part of the base of the cone of ashes. The points (*h*) indicate the sites of powerful *fumarolles*, or smoking fissures, the influence of which tends continually to the destruction of the elevated wall of the Punta del Pálo.

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[1] Vues Pittoresques des Cordillières, &c., p. 291.

[2] See the small map of the Canary Islands, Plate No. 10.

[3] Description Physique des Isles Canaries, par Leopold de Buch.

[4] Baranco (Span.), a ravine or narrow glen. The barancos of Teneriffe seldom contain water, and are rather a sort of fissure in the flanks of the mountains than true glens.

[5] So called, because palm trees appear for the first time in this part of the island.

[6] As the elevation of these mountains is very erroneously stated in many recent works, we subjoin the original measurements, viz., Antisana, 5,833 metres; Rucu-Pichincha, 2,490.3 toises. (Humboldt, Niv. Barom., p. 409.)

[7] Humboldt, Relation Historique, ii. [illegible]

[8] E. A. von Hoff Geschichte der Erdoberfläche, ii. 493.

[9] L. von Buch, Descr. Phys. des Isles Canaries, p. [illegible]

[10] Nivellement Barom., p. 28.

[11] "The great mountain of Pichincha has four principal [illegible] on which M. de la Condamine was for a few minutes, but did not measure; the cone of los Ladrillos, [illegible] Rucu-Pichincha. A fifth peak of a grotesque form, is that against which abuts the crevasse called Cu[illegible] [illegible], Nivellement Barom., p. 103.)

[12] Von Hoff, ii. 495.

[13] Vues illustratives de quelques Phénomènes Géologiques [illegible] Etna. Paris, 1836.

PLAN OF THE CRATER OF ETNA.

This plan, constructed in the same manner as the preceding, represents, in as far as the natural difficulties of the ground would permit, the crater of Etna in the state in which it was left by the eruption of November 1832. Four months after this event, in February 1833, the volcano being in a state of the most absolute repose, there was formed on the summit of the mountain a certain number of hollows of various form and depth. These hollows, following a right line direction, began to show themselves at the Torre del Filosofo, which, as well as the ground on which it is built, is sunk to the extent of nearly 15 feet. They traverse the field of lava, surrounding the cone; then rising to the summit, lose themselves in the interior of the crater, on the side opposite Bronte. The most extensive of the hollows, placed on this line, forms an oval opening (*a*) on the crest of the south-east edge of the crater. This opening, with a diameter of more than 320 feet at its orifice, and of an immeasurable depth, presents vertical walls without inequalities, which admit of easily distinguishing at their surface the section of stratified substances, following two lines of declivity, inclined in two opposite directions—the one towards the centre of the crater, and the other towards the exterior base of the cone. The crater itself, in consequence of the different occurrences mentioned, which have destroyed the north-eastern wall, giving to the cone an oblique and truncated form, presents a most complete appearance of disorder and destruction.

b indicates one of the crateriform openings of nearly 53 feet deep, which have been produced during the last eruption upon the surface of the crater, and which served as a passage to the vapours and the incandescent scoriæ.

c great conical masses of scoriæ, the evident residue of old cones of eruption, which have also been formed by the ejection of scoriæ.

d the place where, at the commencement of the eruption of 1832, the boiling lava in the central chimney opened a passage for itself, by which it commenced to flow over the declivity of the cone, until the flank of the volcano opened 7,460 feet lower, near Bronte.

e represents a breach at the lowest part of the crater, which forms, so to speak, a natural *entrance* into its interior.

f on this point there arises a mass of lava, composed of spheroides.

g indicates the sunken part of the sides of the crater.

h highest ridge of the crater which remains entire.

i i shafts communicating with the interior of the volcano.

k indicates openings similar to those of mine-pits, in connection with the eruption of 1792. They occupy the bottom of a wide crevice.

The largest of these pits, formed like a funnel at the upper part, have an opening in the middle, which is the orifice of a cylindrical tube of 6½ feet diameter, and of an unknown depth. Immediately above these mouths, there is seen to arise, in the middle of a column of elastic fluid, which is disengaged there in great abundance and with a violent noise, a blue flame, evidently produced by the combustion of sulphureous hydrogen gas.

From the base of the cone, the line of subsidence, of which we have spoken above, continues to Torre del Filosofo. It is full of large oval holes of from 32 to 42½ feet deep, and of various diameters, which admit of a very distinct view of the beds of lava placed horizontally, and alternating with beds of scoriæ.

l masses of scoriæ ejected by the lateral eruptions of 1787.

m pit-like openings, which extend to Torre del Filosofo.

SECTIONS OF VESUVIUS AND ETNA.

The sections of the burning volcanoes of Italy, were traced according to the researches of M. Abich, and the barometrical measurements of M. Hoffman in 1832. In both the sections the scales are the same for height as for distance.

FIG. 1. SECTION OF ETNA FROM WEST TO EAST.—The contours of Etna, figured in this section, are exactly the same, in regard to aspect, as those which are observed on the route from Naples to Messina, in the vicinity of the Lipari Islands.

Etna does not present a regular and symmetrical form on all sides. Its central mass rises in the form of an elliptical cone, upon a slightly upheaved surface, above a base of 92,721 feet, in the direction from east to west.

On the east, the soil descends towards the sea, under a highly inclined angle, whilst on the west it flattens, forming a very gentle slope to the calcareous and arenaceous rocks of the secondary formation which skirt the circumference of the mountain, at an absolute height of about 2,131 feet. The central mass, which forms Etna properly speaking, is truncated by an almost plain surface. The cone which terminates the crater does not coincide with the vertical axis of the mountain: it is placed upon the most abrupt slope of this mass. The Val di Bove, that vast elliptical depression on the eastern flank of Etna, is represented in this section in its entire length. The dotted line shows the direction of the slope of the mountain, and the positions of the crests of the interior walls which circumscribe the Val di Bove. Zaffarana is a little village situated at the entrance of the valley.

Portella and Salto di Giumento are the limiting points of the principal divisions of the valley in the form of terraces.

The hatched lines, which run parallel with the dotted line, indicate the inclination of the layers of rock of which the interior of the mountain is composed.

FIG. 2. SECTION OF VESUVIUS.—This section is drawn in the form of a line, which starts on the north of Somma, a village at the foot of La Somma, and terminates on the south at Torre d'Annunziata, on the sea-shore. It is best calculated to give an exact idea of the relative situation of the two masses which compose the group of Vesuvius.

The points of Fontana dell'Olivella and Cancaroni, served as poles to determine more accurately the angle of inclination of the lower part of La Somma. Punta di Nasone is the culminating point of the narrow and somewhat denticulated crest of La Somma. Atrio del Cavallo is the space between the recurvated escarpments of La Somma, and the base of the cone of Vesuvius. Punta del Palo is the most elevated point of the edge of the great crater, and, consequently, of the whole group. Bôcche Nuova indicates the position of the crateriform mouths which were formed during the great lateral eruption which destroyed Torre del Greco. Farther southward is the hill of Cumaldoli, composed of fragmentary substances.

CHART OF SOUTH KEELING ISLAND.

According to the interesting researches of Darwin,[14] this is one of the many singular structures reared by madrepores on the summits of submarine mountains, with which the Pacific and Indian Oceans are studded. It belongs to the class of atolls or lagoon islands, of which class its structure is in most respects characteristic; it is situated in the Indian Ocean, in latitude 12° 5′ south, longitude 90° 55′ east, and its greatest width is nine miles and a-half.

The Keeling atoll, like other coral formations, has been entirely formed by the growth of organic beings and the accumulation of their detritûs. "Every one," says Mr. Darwin, "must be struck with astonishment, when he first beholds one of these vast rings of coral-rock, often many leagues in diameter, here and there surmounted by a low verdant island with dazzling white shores, bathed on the outside by the foaming breakers of the ocean, and on the inside surrounding a calm expanse of water, which, from reflection, is of a bright but pale green colour. The naturalist will feel this astonishment more deeply after having examined the soft and almost gelatinous bodies of these apparently insignificant creatures, and when he knows that the solid reef increases only on the outer edge, which day and night is lashed by the breakers of an ocean never at rest." The reef which essentially forms the atoll is described as a ring encircling the lagoon on all sides except at the northern end, where there are two open spaces, through one of which ships can enter.

This reef varies in width from 250 to 500 yards; its surface is level, or very slightly inclined towards the lagoon, and at high-tide the sea breaks entirely over it. The most frequent coral in the hollows on the reef is *Pocillopora verrucosa*, which grows in short sinuous plates, or branches, and when alive is of a beautiful pale lake-red: a madrepora, closely allied or identical with *M. pocillifera* is also common. As soon as an islet is formed, and the waves are prevented from breaking entirely over the reef, the channels and hollows in it become filled up with cemented fragments, and its surface is converted into a hard smooth floor, like an artificial one of freestone. This flat surface varies in width from 100 to 200 or even 300 yards, and is strewed with a few large fragments of coral torn up during gales: it is uncovered only at low-water. "Nothing can be more singular than the appearance at low tide of this 'flat' of naked stone, especially where it is externally bounded by the smooth convex mound of Nulliporæ, appearing like a breakwater built to resist the waves, which are constantly throwing over it sheets of foaming water." The highest part of the islet is close to the outer beach, and averages from six to ten feet above ordinary high-water mark.

At a distance of 2,200 yards from the breakers, Captain Fitzroy found no bottom with a line 7,200 feet in length; hence the submarine slope of this coral formation is steeper than that of any volcanic cone; and Mr. Darwin infers the existence of submarine cliffs from the sudden increase of depth at some points, and from the line having been cut as if rubbed at certain depths.

CHART AND VIEW OF THE ISLAND OF ASCENSION.

This island, which is entirely of volcanic origin, is situated in the Atlantic Ocean, in latitude 7° 55′ 56″ south, longitude 14° 23′ 50″ west, being about eight miles in length, and six in breadth. The mountain district extends principally over the south-east portion of the island; and the "peak," or highest elevation is 2,870 feet above the level of the sea. The plains or table-lands surrounding the "peak" vary in height from 1,200 to 2,000 feet. On the north side they sweep gradually down towards the shore; but on the south, they terminate in high and bold precipices. The hills dispersed over the island vary in height from 100 to 1,500 feet above the sea. They abound with cinders, scoriæ, and ashes, and are surrounded at their bases with compact and cellular lava, and occasionally obsidian.

The dark and rugged beds of lav[illegible] deep red colour of the hills, the wild and capricious forms of the mountains and precipices, [illegible] prevailing *apparently* recent indications of volcanic action, impart to the aspect of the island [illegible] of total sterility and desolation that does not really belong to it. On approaching it, unde[illegible] of the atmosphere, when dark masses of clouds are congregated round the high peak and bosom of the Green Mountain, and their black shadows are projected far down the plains, so that the only evidence of verdure—the solitary oasis amidst the surrounding desolation—is shut out from the view, it is scarcely possible that the imagination should conceive a picture more wildly sublime.[15] Mr. Darwin, to whose instructive work we must refer for a geological description of the island,[16] mentions that from the central eminence he counted between twenty and thirty cones of eruption, the greater number of which had their truncated summits cut off obliquely, and they all sloped towards the south-east, whence the trade-wind blows; and in treating of the calcareous rocks on the sea-coast, he describes the accumulations of shells and corals, interspersed with volcanic particles, which are found cemented into stone, of which the softer varieties are used for building; and he states that in some of these formations, the eggs of the turtle being buried by the parent, sometimes become enclosed in the solid rock.

The chart of the island is reduced from the survey of Lieutenant Campbell, R.N.; and the view from the drawing by Captain Brandreth, R.E., in the Journal of the Royal Geographical Soc., vol. v.

PLAN OF THE CRATER OF GEDEE IN THE ISLAND OF JAVA.

The volcano of Gedee is situated in the western part of the Island of Java, in latitude 6° 53′ south, longitude 106° 59′ east.[17] It is, according to Dr. Salomon Müller,[18] 9,728 feet in height. All the mountains of Java rise in the form of a tower above the general ridge of the island, which is proportionally of little elevation, since its mean height may be reckoned at not more than 1,600 feet; so that the proportion between the height of the ridge and that of the peak is nearly as one to six.

This volcano affords an excellent example of an eruption cone, and we have succeeded in preserving in the annexed plan, which is reduced only about one-third from the original, all its striking and minute features. The most remarkable of these are the eruption cone and the small crater situated near its centre, which are surrounded on the east, south, and north, by a high ridge, somewhat in the shape of a horse's shoe, and from the interior of which immense streams of lava, occupying a breadth of upwards of 1,500 feet, have flowed in a northern direction. The southern declivity of the crater is decked with shrubs and small trees of different kinds, and the valley of Aloen-Aloen is entirely overgrown with shrubs of *Gnaphtalium Javanicum*.

This valley divides Goënong Gedee from G. Seda-ratoe, the northern slopes of which support tolerably lofty trees.

This plan is from the survey of Dr. Salomon Müller, who with great kindness furnished a copy for the present work. The original appears in the magnificent work on the Natural History of the Possessions of the King of the Netherlands in the East Indies.

PLAN AND VIEW OF GRAHAM ISLAND.

This remarkable volcanic island appeared in the Mediterranean in the month of July 1831, in latitude 37° 8′ 30″ north, longitude 12° 42′ 15″ east, about 33 miles north-east of Pantellaria: and remained visible above the surface of the water for about three months. About a fortnight before the eruption was visible, Sir Pultney Malcolm, in passing over the spot, felt the shocks of an earthquake, as if the ship had struck on a sand bank; and the same shocks were felt on the west coast of Sicily. About the 10th July, the captain of a Sicilian vessel, in passing near the place, saw a column of water like a waterspout, 60 feet high, and 800 yards in circumference, rising from the sea; and soon after a dense steam in its place, which ascended to the height of 1,800 feet. On returning, on the 18th July, he found a small island, 12 feet high, with a crater in its centre, ejecting volcanic matter, and immense columns of vapour. The eruption continued with great violence to the end of July, when it was visited by Captain Swinburne, R.N. At this time it was from 50 to 90 feet high, and three-fourths of a mile in circumference. By the 4th August it became, according to some accounts, above 200 feet high, and 3 miles in circumference. After this it diminished by the action of the waves, and was only 2 miles round on the 25th August. On the 3d September it was reduced to three-fifths of a mile in circumference, and 107 feet in height; and on the 29th September it was only about 700 yards in circumference. At the end of October no vestige of the crater remained, and the island was nearly levelled with the surface of the ocean. At the beginning of 1832 there was a shoal and discoloured water on the spot, and at the end of 1833 a dangerous reef existed, about three-fifths of a mile in extent. From the whole of the facts detailed by Sir C. Lyell, he conjectures that a hill 800 feet in height was formed by a submarine volcanic vent, of which the upper part (about 200 feet high) emerged above the waters, so as to form an island. This cone, he says, must have been equal in size to one of the largest of the lateral volcanoes on the flank of Etna, and about half the height of the Mountain of Jorullo in Mexico, which was formed in the course of nine months, in 1759.[20]

PLAN OF ARTHUR'S SEAT.

Arthur's Seat, in the words of its geological explorer, to whose talented work we have much pleasure in referring for a full and minute description,[21] "is an isolated hill, rising abruptly from a level country, to the height of 822 feet above the sea, with a bold craggy outline; and for grandeur and picturesque effect, is worth all the temples and monuments of London and Paris put together. It is so near Edinburgh, that it may be said to be in contact with the eastern parts of it. The lower part of the hill is chiefly of sandstone; the upper is entirely of trap—that is, of rocks of volcanic or igneous origin, of which the familiar name in this country is *whinstone*." Salisbury Craigs, so called from the fine mural precipice, formed by a bed of greenstone, is, properly speaking, only a part of the same hill, separated by the marshy hollow called the "Hunters' Bog." On the south side of the hill is the beautiful columnar precipice called "Samson's Ribs," of which we have given a vignette view. The plan represents the topographical configuration with greater accuracy than any other map of this interesting hill hitherto published, and the heights of all the principal points are the result of repeated and careful barometrical measurements. The sections are explained by reference notes and colours.

SOUTHERN VIEW OF ETNA FROM MONTE PO, NEAR CATANIA.

In the notes accompanying the large and beautiful drawing of which this is a reduction,[22] S. von Waltershausen has explained as follows the method he adopts for securing accuracy in his designs.

A certain number of points are to be arranged, proceeding from the eye through the central projection, on a vertical plane, which is found at a known distance, and of which the direction in space is determined by means of azimuth and height. The amount of both angles may be easily ascertained by the use of a theodolite furnished with a vertical arc; reckoning the projected points by taking the distance, or the length of the normal from the eye to the vertical plane, which the scale of the intended picture specifies. It is clear that in this way only a limited number of fixed points can be determined, which will prevent the occurrence of gross errors in the relative positions of objects; all beyond this depends on the dexterity and experience of the draughtsman. In order to examine such a delineation, the eye of the observer must be placed at the proper distance, and in the proper position. Here alone can he receive the impression of reality; from every other point it appears more or less a distorted picture.

This drawing is based on nine fixed points, but the azimuths of fifteen other objects were connected with them, the heights of which are only estimated. It embraces the space from M. Arso al Cavaliere to M. Illice di Fleri, and is taken from M. Po, a low hill about two miles west of Catania.

It required a long study of the mountains in order to represent, in outline, the objects which are observed in this drawing, for some of the contours could only be perceived in the clearest sky, during favourable morning or evening light; while others, on the contrary, were only distinctly visible so long as the higher regions were covered with a thick mantle of snow.

Etna is here seen from its southern side, where, without any considerable prominence, it upheaves from its base its central conical mass, on which the still active crater has raised itself by the accumulated deposits of many eruptions. From this there issues a thick cloud of smoke, which, seized and pressed down by the west wind, is driven towards the promontory of Concazzen; but there arrived in a wide vault, it rises and moves towards the distant Calabria. This phenomenon, of which S. von Waltershausen was an eye-witness on the 10th May, 1839, is here reproduced, true to nature. On approaching somewhat nearer, in describing the surface of the mountain, we remark first the crater with its peaks, the form of which is observed to be involved in more constant change, according as the eruptions of the volcano reduce them to a level with itself. On the west side lies the now highest point of Etna; to the east is observed a somewhat lower, sharp, steep peak, which bears the name of Il Dente; between the two lies the deepest part of the crater, which is called Pozzo di Fuoco. From this the lava of 1838 flowed to the foot of the cone, which, in November, 1842, was again partly overlaid by a new current.

The crater stands in the centre of a nearly horizontal plateau, on the southern margin of which lies the Casa Inglese; this is observed in the drawing as a nearly horizontal line, under which project two mountain peaks—on the west M. Frumento, and on the east Montagnuola. The last is the eruption-crater of the year 1763, which has spread itself over the steep precipice of Tacca del Barile and Schiena dell'Asino. The Montagnuola forms the western end of the Serra del Solfizio, which, furrowed by several valleys, stretches out beyond M. Zoccalaro. Over these project the upper parts of Serra delle Concazze. The Valle del Bue or del Bove is enclosed by the two above-mentioned serras or mountain chains.

Under the central mass of Etna we perceive, especially in the middle zone, a considerable number of lateral craters. Among these M. Rosso of Nicolosi, which is distinguished by two very characteristic pyramidal horns, occupies the first place. From this crater, which was formed in the spring of 1669, flowed the immense lava-stream, the wide extended track of which appears in the middle and foreground of the view. It breaks through the olive forests of the cultivated region in several branches, and turns on the west towards Tiriti and Valcorrente, and on the south towards Catania, where it reaches the sea. The surface of these bleak and naked stone-fields which is just beginning, in some places, to bear a scanty vegetation of cactus, broom, and euphorbia, presents, far and wide, a picture of the most frightful desolation, and many centuries must elapse ere it can be again covered with forests and vine terraces.

In the middle part of the mountain we perceive, in the wooded region, between the lateral craters, several other lava fields, which are so conspicuous as to attract the eye at a great distance. Towards the west is observed the current of 1780, which surrounds M. Parmentiddi, and stretches down to M. Mazzo and M. Ragalna.

Near the centre of the sheet lies another great lava field, formed by the currents of 1537, 1636, and 1766, from which several craters project. Lastly, more towards the east there appear three small branches, two of which originated in the year 1634; but the third, not far from Monte Urna, belongs to the eruption of the year 1792.

VIEW OF THE SUMMIT OF THE PEAK OF TENERIFFE.

This view is taken from a point the height of which is above the limits where all sorts of trees cease to grow. It gives an idea of the true form of the last cone of the peak, which is seen in all its extent from so few points. On the left is perceived the steep rocks which form the circumference of the crater of elevation, the most elevated point of which is that of *los Azulejos*. This limit is continued circularly behind the first plane of the drawing.

COMPARATIVE VIEWS OF THE ELEVATION OF THE PRINCIPAL ACTIVE VOLCANOES ON THE GLOBE. These are arranged according to their occurrence in the Eastern or Western Hemisphere, and the elevation of each is indicated by the scale, in feet, above the level of the sea.

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[14] On the Structure and Distri[illegible] London. 1842.

[15] Journal Royal Geographical Society, vol. v., p. 243.

[16] Geological Observations on Volcanic Islands. London. 1844.

[17] See Map of the Volcanic Series of the Old World, sheet No. 10 of this division.

[18] The height is variously stated by other authorities. Dr. Junghun makes it 9,335 feet.

[19] Verhandelingen over De Natuurlijke Geschiedenis der Nederlandsche overzeesche Bezittingen, Door de Leden der Natuurkundige Commissie in Oost-Indie en andere schrijvers. Leiden: J. Luchtmans.

[20] Principles of Geology, vol. ii., p. 208. For further explanation see Description of the Plan and View, by Captain Swinburne, R.N., in Journal Royal Geographical Society, vol. v., p. 209.

[21] Geology of Fife and the Lothians, by Charles Maclaren, Esq., F.R.S.E.

[22] Atlas des Etna, Vorwort und Erklärung der Kupfertafeln, s. 3.

PLATE 12

PHYSICAL CHART OF THE ATLANTIC OCEAN,

FOUNDED ON THE RESEARCHES OF

HUMBOLDT, RENNEL, LARTIGUE, HORSBURGH, PURDY, ROMME, SCORESBY, THE JOURNALS OF THE OFFICERS OF THE ROYAL PRUSSIAN MERCANTILE MARINE,* AND OF THE AMERICAN MARINE AND MERCANTILE NAVY, UNDER LIEUT. M. F. MAURY.

* These comprise various circumnavigations, as well as numerous voyages to North and South America and the West Indies, the original journals of which were kindly communicated by the Chief of the Seehandlungs Institute, Private State Minister Rother.

INTRODUCTORY NOTE.

The basin of the Atlantic Ocean, enclosed between the western shores of Europe and Africa on the one side, and the eastern shores of America on the other, probably extends to the poles of the globe on the north and south, although it is usually described as limited by the Arctic Circle on the north and the Antarctic Circle on the south—the spaces north and south of which are termed respectively the Arctic and Antarctic Oceans. The Atlantic is understood to be separated from the Pacific Ocean by a line drawn through the meridian of Cape Horn to the Antarctic Circle on the west, and another from the Cape of Good Hope to the Antarctic Circle on the east. The depth of this basin varies from 150 to probably upwards of 6000 fathoms. In the North Atlantic, the shallowest parts extend along the shores of the continents, whence it gradually deepens to near its centre—the deepest part being probably between latitude 35° and 40° north, immediately southward from the Grand Banks of Newfoundland. The average depth of the Gulf of Mexico is one mile, the deepest part of the Caribbean Sea three miles, the North Atlantic six miles, and the South Atlantic about three miles. It is estimated that, from the greatest depth yet reached by the plummet, the elevation from the bottom of the Atlantic to the top of Chimborazo, in the Andes, is about nine miles in a vertical line. In the North Sea, the shores of France and the British Isles rest on a submarine plateau, varying in depth from 300 to 600 feet below the surface of the sea; and between Cape Clear in Ireland, and Cape Race in Newfoundland, there is said to be a remarkable steppe, or raised bottom, on which the sea is estimated to be probably nowhere more than 10,000 feet in depth.[1] The southern part of the Atlantic basin appears to be separated from the north by raised bottoms, apparently due to volcanic influence, extending from east to west in the vicinity of the equator, and both north and south of it. (See the Chart.)

The number of soundings in the South Atlantic is not yet sufficient to admit of any deduction as to the form of its floor. West of the Cape of Good Hope the plummet sank to 16,000 feet; and between St Helena and Brazil, Sir J. C. Ross found no bottom at 27,600 feet: but, from the means employed, little dependence can be placed on these soundings.

The middle portion of the basin of the North Atlantic, cut by the parallel of latitude 25° north, and the meridian of longitude 45° west, is so thickly matted with sea-weed (*Fucus natans*), that the speed of vessels passing through it is often greatly retarded. It is so thick, that to the eye, at a little distance, it appears substantial enough to walk upon; and this, together with its vast extent—its area being equal to the valley of the Mississippi,[2] or, according to Humboldt, about six times as large as Germany—alarmed the companions of Columbus, who thought they had reached the limit of navigation.

Since the first edition of this work was published, extensive researches have been made into the physical and economical characteristics of the Atlantic Ocean, under the direction of Lieut. M. F. Maury, Superintendent of the National Observatory at Washington, to whose kind attention in furnishing the most recently ascertained results we are indebted for many of the facts and illustrations presented in the following notes. Such, he observes, has been the advantage to navigation of the *Wind and Current Charts*, furnished to the ship-masters by the United States Government, that "the passage from the United States to the equator has, since their introduction, been shortened ten days. Before the commencement of this undertaking, the average passage to California, from the United States, was 183 days; but, with these charts for their guide, navigators have reduced that average, and brought it down to 135 days. Between England and Australia the average time going, without these charts, is understood to be 124 days, and coming about the same—making the round voyage one of about 250 days." "The outward passage, it has been ascertained, has been reduced, by the use of these charts, to 97 days on the average."[3]

The distances mentioned in the Chart are reckoned in nautical or geographical miles, 60 of which are equal to a degree of latitude. There are 69 statute miles to a degree; hence a nautical or geographical mile is about 6086 English feet, while a statute mile is 5280 English feet. A marine league is equal to three nautical miles; a fathom equal to 6 feet. The temperature is uniformly stated in degrees and parts of Fahrenheit's scale, and the longitude is reckoned from the meridian of Greenwich.

NAVIGATION OF THE ATLANTIC.[4]

In the navigation of the great oceans by wind-propelled vessels, it is a general rule that, in sailing from east to west, it is necessary as soon as possible to enter the zone of the trade-winds, and to endeavour to keep outside of that zone in sailing from west to east. The prevailing winds, and their effects on navigation, are explained in the Chart of the Currents of Air, Plate 19, p. 63—on which also the navigation routes are generalised; and the currents which, by their power of facilitating or retarding a voyage, have an influence little inferior to that of the winds, are described in the following pages. This influence is evidenced by the fact that, since the application of the thermometer to the Gulf Stream, the average passage from England to the United States has been reduced from eight weeks to a little more than four.

FROM EUROPE TO NORTH AMERICA.

The average distance on this route, from longitude 50° west to New York, is 3707 miles; and from 10° degrees west, coming out of Liverpool, 3540 miles. The most difficult parts of the route for navigation are between longitudes 15° and 20°, 25° and 30°, and 35° and 40° west. Calms are most prevalent between longitudes 25° and 30°, and 35° and 40° west.[5]

Early in the year, to make the ports of Nova Scotia, New Brunswick, or the United States, it is recommended to keep north of the parallel of 46° or 47° north till the meridian of about 35° west is attained; thence to steer south to the parallel of 43° north, keeping on or near this parallel, and not getting more to the north, especially on nearing the American coast, in order to pass freely south of Sable Island—the dangers of which must be carefully avoided. On this route the vessel keeps beyond the northern borders of the Gulf Stream; and, after passing the Great Bank of Newfoundland, the voyager is favoured by the arctic current running south-west. Late in the season the route is much farther north than the preceding. (See the Chart.) On quitting Europe, the course is north-west to about latitude 55° north in longitude 30° west. Thence the route is south-west, crossing the Banks of Newfoundland in about latitude 46°, and passing about 70 miles south of Sable Island to the destined port. On these routes it is dangerous to get to the north of Sable Island, on account of the frequent fogs and strong south-westerly currents met with in its vicinity. On the routes from Europe to the United States the voyage is much retarded by the Gulf Stream, the current of which ought to be carefully avoided; for, in case of contrary winds or calms, the vessel would be carried by it rapidly to the eastwards.

The southern route from Europe to America, although much longer in the distance to be traversed, is by some authorities reckoned preferable to the foregoing. On quitting Europe by this route, the object is to steer south or south-west according to the prevailing winds, in order as soon as possible to reach the zone of the trade-winds. The best course for this is that between the Azores and Madeira, or between Madeira and the Canaries, avoiding a too near approach to the coast of Africa, where the wind is feeble and variable. Once in the region of the trade-winds, the course westwards must be shaped in accordance with the position of the port to be attained. See the course of the ship *Christian* on the parallel of 30° north. This course is most advantageous in spring, summer, and autumn, when the regular trades extend to the parallels of 28° and 30° north. On comparing all the voyages of packets between Liverpool and New York for six years, we find that the average time occupied from east to west is 40 days.[6] The following are quoted as fine passages:—The *Charlotte*, from Bremen to New York in two voyages, 33 and 28 days; the *Alexander*, from the Weser to the same port, 27 days; the *Clementine*, from Bremen to Baltimore, 29 days.[7]

FROM THE UNITED STATES TO EUROPE.

On the return-route to Europe from the northern ports, advantage is taken of the southerly currents near the coast in order to enter the Gulf Stream, which is crossed in a north-east direction so as to get speedily out of its current, since unfavourable weather is often met with within its limits, especially during the hurricane season, from July to October. During the other months, however, its current may be navigated by a good vessel with safety, and with greatly accelerated speed. These voyages are much facilitated by the prevailing westerly winds, varying to south-west and north-west; so that the average duration of the voyage by the packets from New York to Liverpool is only 23 days, instead of 40 days on the opposite course. Indeed, the voyage from west to east has been accomplished by packet-ships in 19, 16, and even in 15 days.

From the tables of Lieutenant Maury, it appears that the average European passage in February ought to be nearly two days shorter than it is either in January or March.

According to his Pilot Charts, the average distance to be sailed by a New York packet-ship by the routes, from January to April, not estimating for the set of the currents, is, when bound

TO LIVERPOOL.

In January, 3075 miles to 10° west, for 250 of which a vessel will have winds dead a-head.
In February, 3015 ... ... 234 ... ...
In March, 3150 ... ... 231 ... ...
In April, 3051 ... ... 244 ... ...

TO THE ENGLISH CHANNEL.

In January, 3300 miles to 5° west, for 293 of which a vessel will have winds dead a-head.
In February, 3245 ... ... 261 ... ...
In March, 3448 ... ... 249 ... ...
In April, 3275 ... ... 265 ... ...

According to the log-books taken at random, both of packet-ships and transient traders, the average time between these meridians and New York is found to be as per statement subjoined:—

When bound to Liverpool, average length of passage from New York to 10° west.			When bound from Liverpool, average length of passage from 10° west to New York.			When bound to English Channel, average length of passage from New York to 5° west.			When bound from English Channel, average length of passage from 5° west to New York.		
Month.	Days' passage.	Number of passages.	Month.	Days' passage.	Number of passages.	Month.	Days' passage.	Number of passages.	Month.	Days' passage.	Number of passages.
January	18	25	January	33	16	January	20	11	January	40	7
February	20	18	February	35	36	February	23	6	February	41	13
March	20	20	March	31	41	March	25	10	March	33	10
April	21	9	April	29	17	April	22	6	April	30	2

The same voyages by steam-packets present the following results:[8]

FROM EAST TO WEST.	Longest.	Shortest.
Great Western, Bristol to New York, ...	21½ days.	13 days.
Royal William, Liverpool to New York, ...	21¼ ...	18¼ ...
Liverpool, Liverpool to New York, ...	18¼ ...	16 ...
British Queen, Portsmouth to New York, ...	20¼ ...	14 ...

The screw steam-ship *Great Britain* left the Mersey on the 1st May 1852, and, notwithstanding very unfavourable weather, which rendered her sails nearly useless, she accomplished the passage to New York in 13 days 5½ hours. On the 12th she ran a distance of 301 miles in 24 hours—a speed previously unattained by screw steamers. (See track from her log on the chart.)

FROM WEST TO EAST.	Longest.	Shortest.
Great Western, New York to Bristol, ...	15 days.	12 days.
Royal William, New York to Liverpool, ...	17½ ...	14½ ...
Liverpool, New York to Liverpool, ...	17¼ ...	13¾ ...
British Queen, New York to Portsmouth, ...	22½ ...	15¾ ...

The number of steam-vessels wrecked, by collision, in crossing the Atlantic, has caused great anxiety as to the best means of preventing a recurrence of the calamity,[9] and Lieutenant Maury having been called upon to offer his advice, has drawn up a judicious and practical scheme for establishing steam-lanes, in which he says:—

> The logs of the Collins and the Cunard lines show that the part of the ocean used by them in their voyage to and fro, between the meridians of 15° and 65° west, is, for the American, 300 miles, and for the English, 150 miles broad. The American roadway overlaps and includes the English, consequently there is a breadth of ocean 300 miles wide, in any part of which a sailing vessel, by night or in a fog, is now liable to be brought into collision with steamers. He proposes to take this same breadth of ocean, and lay off a lane twenty or twenty-five miles broad near its northern border, and another, fifteen or twenty miles broad near its southern border, and recommends the steamers, when going westwardly, to use the former, and when coming eastwardly to take the latter. The adoption of these lanes might not *do away* with collisions, or relieve in any manner the shipmaster from his obligations to look closely to the navigation of his vessel, but it would diminish the chances of collision, and make the navigation of the Atlantic less dangerous. The breadth stated is just enough to cover the probable errors in latitude of a careful navigator, after he has been two or three days without an observation. A narrower lane would be forbidding, from the difficulty of keeping in it; a broader one would be mischievous, by relaxing its calls upon the attention of the master to keep his steamer in it, and by occupying so much of the ocean that sailing vessels would not so willingly give it up to the steamers. If these lanes were adopted by the steam-ship companies, and engraved on the general charts of the Atlantic, there is little doubt that sailing vessels would, in the process of time, make it a rule to edge off from the lanes, especially at night and in thick weather. In the first place, the lanes are so narrow, that if the sailing vessel have to cross, she will be but a little while in them, and her master will then know on which side to watch for the danger. In the next place, if his course lie along the lane, and the winds be fair, he will, as night comes on, or as the weather grows thick, begin to think of the steamers and collision, and his own responsibilities, and then feel much more comfortable by edging off to one side, and leaving the steam-track clear.
>
> The average route of the steamers coming, as determined by the abstract logs, crosses the meridians of 40°, 45°, and 50°: from forty-five to sixty miles north of the lane to America, and joins it on the meridian of 55°, and then runs nearly along with it to Sandy Hook.
>
> The lane coming is, therefore, a better road than the average route at present used, for it is thirty miles shorter; it runs so far south of Cape Race (100 miles) and the Virgin Rocks, that no time need be lost in turning aside, when fogs prevail, to avoid these dangers.
>
> The shortest distance possible for a steamer between Liverpool and Sandy Hook is 3000 miles; the average distance actually accomplished is 3069 miles; and the distance by the middle of the lane is 3038. Another recommendation in favour of this lane to the west, is that it lies along the northern edge of the Gulf Stream, where there is an eddy setting to the westward often at the rate of a knot an hour.
>
> It will be observed, by looking at this lane on the Chart, Plate A, p. 45, that the Grand Banks afford a pretty good landmark, which can be used in the thickest weather, for generally the water thermometer is found to fall on nearing them, and as the eastern edge runs north and south, it affords an excellent correction for longitude. Having ascertained, by the lead, when the vessel first strikes this edge, then noting the soundings and the distance run before clearing the Grand Banks, the latitude will also be known with accuracy sufficient to enable the navigator to decide whether he be in or out of the lane, and if out, on which side. The lane crosses the Banks near their greatest width, 275 miles. If a steamer be crossing there in a fog, and in doubt as to her position, she can judge, by their breadth and the soundings, pretty nearly as to latitude. For instance, if the breadth of the Banks when crossed be less than 275 miles, but the soundings not less than forty fathoms, the vessel has crossed the Bank to the north of the lane; but if she find herself in less than thirty fathoms, then she has crossed to the south of it. Should she, however, find herself in water that suddenly shoals to less than twenty fathoms, and as suddenly deepens again, then she is near the Virgin Rocks, or the rock and Nine Fathom Bank to the east of them, and her position is immediately known.
>
> These lanes are not channel-ways in which steamers must keep or be lost. Gales of wind, ice, and other things, will now and then force a steamer out of them, and in such cases she will actually be where she is now, for she will then be in no more danger than she is now, only when she gets back into the lane she will be in less.
>
> The track on the chart shows the advantageous position of the fork to Halifax, in the lane from Europe. As this lane approaches Newfoundland it edges off to the south, in such a manner as to render it impossible for a vessel so to miss her way as to get ashore. In the longitude of the Grand Banks, the lane to Europe is 200 miles south of the lane to America. As a rule, this lane for the eastern-bound steamers can be followed always. It will be observed that this lane runs E. 15° S. from Sandy Hook to the meridian of 70°, where it takes a course E. 12° N., toward its junction with the arc of a great circle south of the Grand Banks. Though the distance by this lane from Sandy Hook to this junction is a few miles longer than the direct line, yet on account of the Gulf Stream it is in *time* the shortest distance that a steamer can take. From the Capes of Delaware it is obviously the shortest. The distance from Sandy Hook to Liverpool by this lane is 106 miles greater than it is by the lane going. But the lane coming is in the Gulf Stream, which of itself will nearly, if not quite, make up for this difference. The *San Francisco* steamer was wrecked in the Gulf Stream, and from the time she was disabled till she was abandoned, she drifted at the rate of two knots an hour. When the *Great Western* steamship first crossed the Atlantic, she stemmed the Gulf Stream, and was set back in it 175 miles during the voyage. Now, from the Grand Banks west, the track of the *Great Western* was not as much in the strength of the stream as this lane is, for she passed to the north of it. This trip, too, was in April, when the middle of the stream is well south.[10] The current of the Gulf Stream is not only in favour of the lane coming, but the gales are more favourable, and the fogs less frequent than they would be by a more northerly route.
>
> In order to judge as to the relative merits of these two lanes in this respect, Lieut. Maury has examined and discussed abstract logs containing observations for no less than 46,000 days, on the winds, weather, the sea, and the currents, in the parts of the ocean through which these lanes pass. The result of that discussion shows that the preponderance of fair gales along the lane to Europe, viz. all gales having westing in them, is very striking. The vessel will be running with these gales, and therefore diminish their strength. In like manner, gales with easting in them are much less frequently met with in the regions through which this lane passes. Another remarkable physical fact which experience has proved, and these statistics have developed, is that fogs and gales, in certain parts of the lanes, seldom come together. This feature is very striking all the way from the meridian of 25° to that of 55°.
>
> The part in which the lane coming from America to Europe lies is very much frequented by sailing vessels, but it is frequented mostly by vessels coming. (See Chart of Atlantic Ocean and Plate A, p. 45.) Those that are going to the west, seek, for the most part, to avoid the Gulf Stream, either by keeping to the north, or by taking what is called the southern route, which is very common, especially in winter. So that steamers, when in the lane coming to Europe, will find the vessels generally all bound the same way; and likewise in the lane going to America, the vessels seen, though not so many, will, for the most part, be steering to the westward. And when all are bound the same way, collisions are rare.
>
> According to the tables, the best routes for sailing vessels to Europe run along, for the most part, south of the line coming, to the meridian of 45°, between which and 40° they cross this lane, and run along between it and the other. These are the tracks that are projected on Plate A, in which the dotted line represents the centre of the lane.
>
> From computations founded on statistics touching the velocity of the Gulf Stream, it appears that, if two steamers bound for Cape Clear, and of exactly equal speed, were to start from Halifax, to see which should first get into the great circle part of the lane to Europe from New York, and if one were to go straight for it by steering east, and the other were to follow the European lane from Halifax as projected on the chart, this one would reach the point of destination quite as soon as the other, the drift of the Gulf Stream compensating for the greater distance.
>
> Besides the detour from the great circle, which a vessel from New York, Halifax, Boston, or Philadelphia, would necessarily make by following the European lane to Cape Clear, it would require an *additional* detour of only 15 miles for vessels bound into the English Channel to use it also as far as Cape Clear. This lane, therefore, will, in consequence of the favourable currents of the Gulf Stream, put a vessel into Southampton quite as soon as she could reach that port from New York or Philadelphia by the great circle route. Vessels from Halifax will have to make the greatest detour of any by adopting the lane to Europe; but for them it is less than 100 miles out of their way as they now go, and it will prolong their average passage eastwards perhaps two or three hours. It seems, therefore, that the attractions of this lane, as it regards safety, should more than outweigh the *probable* loss of an hour or two during the passage.
>
> The one lane will practically shorten the distance from Cape Clear to Sandy Hook and the Delaware by 30 miles, while the other prolongs the distance going to Europe 75 miles; which prolonged distance, when measured, not by safety, but *in time* alone, the Gulf Stream, better weather, and diminished frequency of fogs, will more than compensate for; and these lanes, if properly followed, will make the average length of passage, as determined by the mean of all for the year, probably less each way, certainly not more than an hour or two longer than it now is. Individual passages will perhaps not be made so quickly as they have been, but on the average, trips will be shortened.

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[1] This has been, perhaps hastily, called the "telegraphic plateau," from the projected submarine telegraph across the Atlantic. The distance from shore to shore by the great circle route is 1600 miles; and it is believed that, while the depth is not so great as to prevent the wires from sinking down and resting on it, it is yet sufficient to guard them from the disturbing effects of currents or icebergs; but the number of soundings is not yet sufficient to warrant this deduction.

[2] Maury.

[3] See Maury's Sailing Directions, 8vo, 1854; and his Physical Geography of the Sea, 8vo, 1855.

[4] Many of the facts regarding the duration of voyages are given on the authority of M. Daussy, chief hydrographical engineer to the Depôt de la Marine, Paris.

[5] See Maury's Sailing Directions, 1854, p. 401. These deductions are collected from upwards of 30,000 observations.

[6] Hodgson's Letters on North America, vol. ii. p. 345.

[7] Journal of the merchant ships of the Hanseatic towns.

[8] The first steam-ships which crossed the Atlantic were the *Sirius*, which left Cork, in Ireland, on the 4th April 1838, and the *Great Western*, which left Bristol, in England, on the 8th of the same month: they both arrived at New York on the 23d of April. This event formed a new era in navigation, and was the commencement of a novel and expeditious mode of intercourse between England and the United States.

[9] In 1852 the number of vessels wrecked on the coasts and in the seas of the United Kingdom alone was 1115. Of these 500 were total wrecks, 33 sunk by collision, making the number totally lost 533. Vessels stranded and damaged so as to require to discharge cargo 558, by collision 24, total 582; making the whole number of wrecks 1115. The loss of life, as far as can be ascertained, was 920.

[10] The thread or axis of the Gulf Stream moves up and down in declination as the sun does, being farthest north in September, farthest south in March.

EUROPE TO THE WEST INDIES AND THE GULF OF MEXICO.

In sailing from European ports to the West Indies and the Gulf of Mexico, vessels, immediately on reaching the Atlantic Ocean, direct their course to the south-west, in order as soon as possible to arrive in the region of the north-east trade-winds. On this part of the route a too near approach to the African coast must be avoided, because the currents there draw in-shore, and the winds have a more westerly direction. Having attained the trade-wind region, if the voyage be directed to the Little Antilles, the course is directly west, keeping as long as possible in the parallel of about 18° or 20° north from May to December. From December to June, on the contrary, a lower parallel must be followed. If the ship is bound for the Great Antilles, or the ports of the Gulf of Mexico, it enters the Caribbean Sea by the channel between Guadeloupe and Antigua, or between St Martin and the Isle de la Culebra. These entrances are invariably preferred in the voyage to St Thomas, Porto-Rico, Port-au-Prince, Kingston, Havana, Tampico, Vera Cruz, and New Orleans. For La Guayra, Porto-Cabello, Carthagena, or other ports in Venezuela, the entrance is generally by the channel between St Lucia and St Vincent. From Europe to Guiana the usual course, from November to July, is to cut the parallel of 10° north between the meridians of 48° and 50° west, in order to cross the zone of calms in the west. From July to November it is sometimes advantageous to sail 150 leagues to the west of Cape Verde, thence the course is south to cross the belt of the variables, and attain the south-easterly winds, which at that season are felt as far as 5°, 6°, or even 8° north; with these winds the voyager steers west between the equator and the parallel of 3° 30′ north. Navigation within the Antilles, from west to east, is attended with great difficulty, on account of the opposition of the trade-winds and the currents. In one case a ship occupied eleven days in sailing from Kingston, on the south side of Jamaica, to Port Maria on the north side. A ship bound from Jamaica to the Little Antilles cannot make the voyage within the Caribbean Sea, along the south side of Hayti, but must steer through the windward passage, and along the south-east of the Bahama Isles into the ocean, and then take a northerly course to the Tropic of Cancer, or even to the parallel of 25° north, whence the course is directed southwards. On this voyage, from west to east, almost as many weeks are required as days in an opposite direction.

If the voyage from the Canary Isles to the Little Antilles, Guadeloupe, and Antigua, occupies from eighteen to twenty days, and that from Teneriffe to Cumana can be accomplished in twenty-two days, the voyage from Kingston to the Danish island of St Thomas will require twenty-five days; although in the latter case the direct distance is only 680 miles, whilst in the former the whole breadth of the Atlantic Ocean has to be passed over.

From the West Indies and Venezuela to Europe, the usual outlet from the Caribbean Sea is by the channel between Guadeloupe and Montserrat. Thence, by the aid of east and north-east winds, the route is towards the north, in order to get out of the zone of the trade-winds. On reaching the zone of the variables, the course is by the usual return-route from North America.

Ships bound from La Guayra, Porto-Cabello, or Cumana, for Europe, quit the Caribbean Sea by the Mona Passage between St Domingo and Porto-Rico, thence the course is north-east, cutting the parallel of 40° north between the meridians of 28° and 33° west. From Cuba and the Gulf of Mexico the Atlantic is entered by the Bahama Channel; the vessel next steers north-east to avoid the Gulf Stream; the course is then south-east, passing south of the Bermudas, and cutting the Gulf Stream again near the Azores. The following affords a general idea of the time occupied in the voyage between the ports of Europe and the West Indies and Gulf of Mexico, and return. From the mouth of the Elbe to Havana, 50 days—return, 49 days; Hamburg to La Guayra, 50 days; Brest to St Domingo, 46 days; Havre to Vera Cruz, 40 days; Brest to Martinique, 27 days; Kingston to Brest, 32 days; Havana to Gibraltar, 47 days; Vera Cruz to London, 42 days; Guadeloupe to Brest, 33 days; Martinique to Brest, 30 days; St Thomas to Hamburg, 45 days, but a voyage by the Prussian ship *Elizabeth Louise* was performed in 36 days.

ROUTES FROM EUROPE TO SOUTH AMERICA.

Vessels bound for Rio de Janeiro, or Buenos Ayres should sail between south and west, in order as soon as possible to get into the north-east trade-winds, passing between the Azores and Madeira, or Madeira and the Canaries, and keeping west of the latter archipelago. Thence the route traverses the zone of variable winds near the equator. It has long been the rule to cut the equator in longitude 18° or 20° west, but numerous examples show the advantage of cutting it rather, as recommended by Lieutenant Maury, in about longitude 30° west, where the zone of the variables is narrower than near the coast of Africa, and the fear of being carried to the west by the current off Cape St Roque has been shown to be unfounded, no difficulty being now experienced in doubling that Cape, especially between the months of October and March. From the United States to Rio de Janeiro, the average passage to the equator for the year, by the old route, was 41 days; by that given in Maury's Wind and Current Charts it is reduced to 30 days. The shortest distance to the equator by the latter, for December, is 3918 miles, but the average distance to be sailed, on account of adverse winds, is 4115 miles. The ship *Bothnia*, in December 1850, accomplished it in 29 days and 4077 miles per log. By the new route for February, the shortest distance is 3674 miles; average distance to be sailed, 3793 miles. This is the most favourable route, and the passage has been made in 17 days. July is the most unpropitious month for a speedy voyage. The average crossing-place on the equator by the tables for the new route is longitude 30° 5′ west.

Vessels from Europe or America, bound round Cape Horn, should, after leaving Cape St Roque, aim, if the winds will let them, to cross latitude 25° south in about longitude 35° west, or as far off the land as they can go without getting east of longitude 33° or 34°. After passing the parallel of Cape Frio, they should steer south, aiming always to pass *inside* of the Falkland Islands,[1] and, if wind and daylight serve, through the Strait of Le Maire. The difficulty in this route, after passing the parallel of Tierra del Fuego, is to get to the westward, for the prevailing winds encountered in doubling the Cape are westerly, which, being interrupted by the Andes, come round the Cape in violent sweeps, puffs, and gales. Hence it is better to make westing on this side, when practicable, than to put it off for the stormy latitudes, where it is more difficult. Vessels bound for California should cross the parallel of 50° south between the meridians of 80° and 90° west in the Pacific. The best months for doubling Cape Horn are our winter and summer months, excepting July. October is the most unpropitious.

Having doubled Cape Horn, vessels bound for California, part in latitude 50° south with those bound for the ports of South America: the former should endeavour to enter the south-east trade-wind region as far to the west as possible, provided they keep east of 115° or 120°; after crossing the parallel of 35° south, the navigator should make the best of his way to the equator, endeavouring to cross it between longitude 105° and 125°, according to the season of the year. The distance from latitude 50° south in the Pacific, to the usual crossing-place on the line, is 3500 miles; the average time 27.8 days, and the mean daily run 126 miles. The winds between latitude 50° south and the equator are so much more strong, steady, and reliable in the Pacific, than on the Atlantic side of the continent, that it is as easy to make 3500 miles sail with them in the former ocean as 2900 miles in the latter.

Taking the average of all classes of ships which sail, according to the routes laid down in Maury's Wind and Current Charts, from the United States to California, we find it gives 136 days, while before these investigations were entered into the average was 180 days. This route, since the discovery of the gold fields, has become the "great race-course of the world;" and astonishing feats have been performed on it by the modern American clipper-ships, which in speed have rivalled, if not outstripped, steamers. The shortest passage yet made between the United States and California, and the most wonderful on record for any part of the world, was that of the clipper-ship *Flying Cloud*, which made the passage from New York to San Francisco in 89 days and 21 hours. She sailed from the United States 1st June 1851, passed the Falkland Isles on 26th July, was round Cape Horn on the 24th, and crossed the equator in the Pacific between 120° and 125° west, on the 12th August. For 26 days consecutively this ship averaged, according to her abstract log, 374 knots, or nautical miles, equal to $433\frac{1}{4}$ statute miles, which gives the extraordinary feat of a vessel under canvass having averaged $15\frac{7}{12}$ nautical, or 18 statute miles per hour. Another instance of remarkable speed is that of the clipper-ship *Sovereign of the Seas*, which, leaving Oahu, in the Sandwich Islands, on the 13th February 1853, made the run to New York in 82 days. After crossing the parallel of 48° south, she got within the range of the steady westerly winds of the Southern Ocean, and here commenced a succession of the most extraordinary runs ever recorded. From March 9th to March 31st, between the parallel of 48° south in the Pacific and 35° in the Atlantic, during an interval of 22 days, she made 29° of latitude, and 126° of longitude: her shortest day's run during the interval (not by log) being 150 knots. All this time the wind was steady and fresh from the westward. In 22 days that ship, under canvass, and with the winds alone as a propelling power, accomplished the enormous run of 5391 nautical, or 6245 statute miles (one-fourth of the distance round the earth), and making the daily average of 283 statute miles and nine-tenths (283.9). During eleven of those days, consecutively, her daily average was 354 statute miles; and during four days, also consecutively, she averaged as high as $398\frac{3}{4}$ statute miles. From noon of one to noon of the next day, the greatest distance made was 362 knots, or 419 miles, and the greatest rate reported by the captain is 18 knots, or 21 statute miles per hour. "This is pretty fair railroad speed."[2] The average rate of sailing among the ancients was 35 miles per diem.[3]

RETURN ROUTES FROM SOUTH AMERICA TO EUROPE.

Vessels which leave the ports of Brazil situated north of Cape Olinda may in general steer directly north; but those which leave the Brazilian ports south of this point are often obliged by the north-east winds to sail south-east and south-south-east, to the parallel of 28°, and even to 32° south, in about longitude 28° west, in order to be sure of doubling the island of Trinidad. The farther north the vessel sails, so much more will the wind be from the east, which facilitates the voyage; and it seldom occurs that she cannot double the island of Fernando-de-Noronha, and cut the line between the meridians of 28° and 33° west. Thence the course traverses the belt of variable winds, and the voyager, by the help of the north-east winds, attains the parallel of 30° north, and passes through the channel of the Azores, or north of that archipelago, according to his destination.[4] The average time on the voyage from the different ports of Europe to Rio de Janeiro is 50 days; but the packets from England to Rio perform the voyage in 35 days. The average-time from the ports of Europe to Cape Horn is 82 days; from Marseille to Rio, 65 days; from the Strait of Gibraltar to Santa Catharina, 53 days; from Brest to Cayenne, 31 days. From the ports in the north of Brazil to Europe the average is from 33 to 37 days; from Rio de Janeiro to Brest, 48 days; Monte Video to Havre, 82 days; Cayenne to Brest, 56 days; from Cape Horn to Europe, 73 days.

FROM PANAMA TO CALIFORNIA AND THE NORTH-WEST.

The passage under canvass from Panama to California, as at present made, is one of the most tedious, uncertain, and vexatious that is known to navigators. The voyage from Valparaiso to California, though double the distance, is shorter in point of time. The former passage is seldom made under 90, and often extends to 120 days. One of the clipper-ships made the passage in 45 days by standing to the southward as if bound to Callao, and making all her westing in the south-east trades, south of the line; but this is such a round-about way of getting from Panama to San Francisco, that Lieutenant Maury thinks it indicates a great want of knowledge as to the winds and currents on the northern route. He suggests that from January to June the passage should be south of the equator, for in this half of the year the north-east trades and equatorial doldrums are often found between the equator and latitude 5° north.[5] Mr Findlay[6] quotes the case of "the barque *Emily*, of London, which sailed from Panama for San Francisco, March 7th 1852, and after being out 95 days, put into San Blas with nineteen of the passengers *dead from starvation*. The remaining passengers were then transferred to the *Archibald Gracie*, and were 65 days more on their passage to San Francisco, during which eighteen more of these unfortunate people died: the suffering endured is almost beyond description." He adds, "Yet the route pursued, we believe, was that stated to be a proper one to Captain Basil Hall by a local authority."

ROUTES BETWEEN CALIFORNIA AND AUSTRALIA.

The great circle distance from South Australia to California is about 7000 miles, but the distance to be sailed in going, on account of the detours, for the sake of winds, is about 7500 miles; returning—that is, coming this way by the eastern route—the distance is 800 or 900 miles greater. With the exception of the north-east trades in the passage from New South Wales or Victoria to California, the winds are fair, or may conveniently be made so, both ways. Returning from California to Australia, the course out of San Francisco is as soon as possible to get down into the north-east trades, as if bound for China or India, crossing the equator between 140° and 150° west, and the parallel of 30° south in about the meridian of 170° east; thence the course is, between Australia and New Zealand, direct for port. In these passages navigators have to cross the calms of Cancer and of Capricorn, as well as those of the equator; which last occur between the north-east and south-east trade-winds, but upon different parallels, according to the season of the year.[7] The barometer will often enable the navigator to tell when he has crossed these belts of calms and entered the trades, for in the equatorial calms there is an ascending column of air, since the atmosphere which the north-east and south-east trades pour into this belt rises up and flows off by counter-currents in the upper regions. Hence the mean height of the barometer in the equatorial calms is less than its mean height in the trades on either side. This difference does not exceed 0.1 of an inch. In the calms of Cancer and Capricorn, on the contrary, there is a descending instead of an ascending current of air, hence the barometer ranges higher, on the average, within these two calm-belts, than it does anywhere else: the difference here also is not more then 0.1 of an inch. There is no route on which close attention to the barometer, while crossing these calm-belts, will be of more service to the navigator than this. The average passage between Australia and California is from 40 to 45 days.

ROUTES FROM EUROPE TO THE PORTS OF NORTHERN AFRICA.

Doubling Cape Finisterre 35 to 60 leagues to the west, according to the season, the route is principally between south and south-west, keeping clear of the coast of Portugal, especially in winter, and thence either east or west of the island of Madeira, or through the Azores, within sight of which nearly all the vessels bound for the African coast pass. After crossing the parallel of lat. 19°, advantage is taken of the North African current to sail toward the south-east. From Cape Verde the navigation becomes in a manner local, easy with the north-east winds in the fine season, but difficult during south-west winds in winter. Vessels bound for Northern Guinea or the islands of the Gulf of Biafra, after having passed Cape Verde, make for Cape Palmas, which they pass 20 to 100 leagues from the coast, according to the season; thence, assisted by the Guinea current, which flows south-east, the course is between the parallels of 3° and 2° north. In order to leave the Gulf of Guinea, across the current, the object is to reach the equator by the most direct course. From May to December the route may be on the line, or a little north of it; but during the other months it is necessary to keep south of 30′ or 1° of lat. The route is then to the meridian of 16°, 17°, or 23° west, according to the port of destination in the North Atlantic. The average voyage from the ports of Northern Europe to Madeira is 15 days; from the Strait of Gibraltar to Madeira, 4 or 5 days; from the ports of Northern Europe to the Canary Isles, 16 days; from the Strait of Gibraltar to the Canaries, 7 days; from the ports of Northern Europe to Cape Verde, 20 days; to the Gambia, 24 days.

From Europe to the ports of Africa south of the equator the routes are very different, according to the latitude of the ports. The *Great Route* is that which conducts to the Cape of Good Hope, and generally to all the ports south of Cape Negro; the *Little Route* is that adopted to the ports north of Cape Negro. On the *Great Route*, vessels follow the course already indicated from Europe to Brazil, cutting the line between longitude 23° and 27° west; thence, assisted by the south-east trade, they make for the island of Trinidad, which is passed on the west, in order, south of it, to take advantage of the westerly winds and southerly currents. Thence for the Cape of Good Hope the parallel of 30° south is cut by the meridian of about 18° west. On this route vessels reach Cape Town in 59 days from the English Channel. On the voyage from Europe to the islands of the South Atlantic 100 days have often been occupied, in ignorance of the best routes. From Europe to the island of Ascension it is necessary to get speedily into the zone of the north-east trades, passing between the islands of Cape Verde and the continent, or to the west of these islands, then doubling Cape Palmas, and making as much southing as possible, in order to cross the zone of the variables, without going further to the west than the meridian of 12° or 14° west. In the vicinity of Cape Palmas, and even to the north of it, south-west and south-south-west winds generally prevail; with these the line may be cut in longitude 6° or 5° west, and often even farther east, if advantage be taken of the currents of the Gulf of Guinea. In this way the island of Ascension may be easily reached.

From Europe to St Helena there are two routes, depending on the season. The position of this island in the region of the south-east trade-winds renders it impossible for a sailing vessel to approach it from the north, without making a long detour to the east or west. (See routes on Plate 19.) The speed of the voyage depends generally on the time employed in crossing the zone of variable winds and calms. The season, therefore, must determine the route to be preferred: that by the west is always practicable, but the eastern route is recommended only from November to March, at which season the belt of calms is narrowest. The eastern route in the above months is the same as that for the island of Ascension, only keeping longer near the coasts of Africa—as long, indeed, as the wind will serve. By this route the voyage is generally more rapid than by the west; but when the sun has great northern declination, the east route becomes so very uncertain that the west route is to be preferred. Having cut the line between 23° and 27° west, the course is towards the coast of Brazil, then south-east to latitude 23° south, and afterwards north-east and north, so as to make the land, by the assistance of the winds and currents, on the east of St Helena, passing by the south. The average duration of the voyage to the Cape of Good Hope, from a great number of examples, is 90 days. Captain Horsburgh, in the *Anna*, made the passage in 59 days—one of the shortest on record. The average voyage to St Helena is about 60 days.

From the Cape of Good Hope to Europe.—On entering the Atlantic from the Indian Ocean in the fine season (October to April), the vessel may without fear be steered north, so as to double the Cape. But if the passage is made in winter (June to September), it is prudent to steer first to the west 40 or 50 leagues from land, in order to escape the effects of the north and north-west winds frequent at this season. Having doubled the Cape in summer, the course is towards St Helena, which may be passed at a little distance either on the east or west; thence the course is about north-west one quarter north, in order to pass 12 or 13 miles to the east or west of Ascension, cutting the line between 23° and 28° west. On doubling the Cape between the months of April and September, keeping clear of the coast as already stated, the vessel steers south of the zone of the south-east trade-winds, so as to cut the parallel of latitude 20° south, in the meridian of longitude 18° west. At this season the average of numerous voyages is about 70 days from the Cape to Europe. From the Cape to St Helena the average is 15, from St Helena to Ascension 6 days.

From the Cape of Good Hope to the Coasts of North America.—On leaving the Cape between the months of October and April, south-east winds will generally be found to prevail, and the direct route is that indicated for the return to Europe till the line is cut in longitude 28° west; thence the voyage is assisted by the trade-winds blowing generally east and east-north east, passing well to the windward of the Little Antilles. (See Plate 19). If the Cape be doubled in winter, when the north-west winds blow with violence, the voyager must steer south of the trade-wind region, in order to reach the parallel of 20° south in the meridian of longitude 18° west; the route is then north, so as to cut the equator in longitude 33° west, which at this season is preferable to any point farther east. On making for Nova Scotia, it is better to pass to the east than to the west of the Bermudas, since at that season easterly winds prevail. It is usual to pass east of the Bermudas on the voyage to any of the ports of North America north of New York.

ROUTES FROM EUROPE AND THE UNITED STATES TO AUSTRALIA.

From the Atlantic ports of the United States or from Europe, to South Australia, the distance, whether by Cape Horn or the Cape of Good Hope, is from 12,000 to 13,000 miles. The best way for vessels *viâ* the Atlantic to *go* is by doubling the Cape of Good Hope; and the best way to *come* is *viâ* Cape Horn; because the prevailing winds in the extra-tropical regions of the southern hemisphere are from the north-west, which makes fair winds for the outward-bound around the Cape of Good Hope, and fair winds for the homeward-bound around Cape Horn. The best route, in returning homeward by way of Cape Horn, is to get south of the parallel of 45° or 50° as soon as possible, passing south of New Zealand if the wind is suitable; but whether passing south or north of these islands, after getting clear of them the course should be shaped direct for Cape Horn. The further south of the middle of a straight line on the chart from Van Diemen Land to Cape Horn, the nearer the course will be to the great circle route, which is shorter by 1000 miles than by the straight course on the Charts. As a rule, the further south the vessel goes the shorter is the distance, and (at least as far as 48° south) the more favourable are the winds. Hence the Cape of Good Hope will be found to be 1000 miles or more to the northward of the shortest route. In corroboration of this remark, it has been found that the ten shortest voyages out have been made in the maximum latitude of 51°. This latitude has the further advantage of avoiding a region of frequent storms, recently discovered to extend southward from the Cape to latitude 48° south. From the comparison of numerous journals of voyages on the homeward route by Cape Horn, it appears that the maximum latitude of 60° or 61° should be adopted only in the Austral summer months of December, January, and February. At other periods of the year the composite route of latitude 57° should be preferred.

The ocean steamers have, till lately, made their voyages without regard to the prevailing winds, taking the shortest route out, and returning by the Cape of Good Hope, because it is about 7 per cent shorter than by Cape Horn; but it is calculated that, were steamers to follow the best sailing route, steam would only be required for about 3000 of the 13,000 miles of distance. Steamers now therefore return from Australia *viâ* Cape Horn.[8] An important inquiry relative to Australian navigation is the amount of impediment from ice in the southern seas. According to Mr Towson's researches, it appears that no part of these seas south of latitude 40° is entirely free from icebergs; and that while, on any part of the route to and from Australia, icebergs may be met with, yet, in one space forming a spherical triangle, having one of its arcs extending from latitude 30° south longitude 30° west, to latitude 61° south longitude 100° west (see Chart, p. 47), they are so abundant that it can scarcely be traversed without danger. These dangers, however, can always be avoided by a careful use of the thermometer, which indicates not only the vicinity of ice, but, by its comparative depression, the amount of ice to be encountered. In one instance, when thirty-nine icebergs were met with, the temperature fell in their vicinity 8° or 9°. In as far as yet ascertained, it appears that, in the Austral summer months, ice is oftener met with in the lower than in the higher latitudes; and Mr Towson refers to the ship *Golden Era*, which, in the Austral spring month of September, met with no impediment from ice in the extraordinary latitude of 63° south, while in November, in the same longitude, but 7° nearer the equator, the *Great Britain* passed 200 icebergs; and he infers that, in the months of December, January, and February the parallel of 60° between Australia and Cape Horn is more free from ice than some of the lower latitudes, whilst in the Austral winter months the parallels of 56° or 57° are to be preferred in this respect. The icebergs of the southern seas are described as of extraordinary size, and the *Great Britain* is said to have passed one in August 1854 in latitude 45° south longitude 44° west, estimated to be fifty miles long, four miles broad, and one hundred and fifty feet high. It was covered with gigantic seals

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[1] Vessels which go east or outside of the Falklands, though they reach the latitude of 50° sooner, lose all they gain in getting west after clearing these islands. The average time to latitude 50° in the South Atlantic is 7, and thence around the Horn 20 days. The average of six vessels which took the inner route in July is 20 and 17 days, hence a gain of 4 days by the inner route.—Maury's *Sailing Directions*.

[2] Maury, in London Geograph. Journal, vol. xxiii., p. 241.

[3] Rennel, Geog. of Herodotus.

[4] Pilote du Brazil, par M. l'Amiral Baron Roussin.

[5] Sailing Directions, p. 734.

[6] Journal of Royal Geograph. Society, vol. xxiii., p. 235.

[7] See the Chart of the Currents of Air, Plate 12, p. 61.

[8] Towson on Great Circle Sailing. Liverpool, 1855. (For private circulation.)

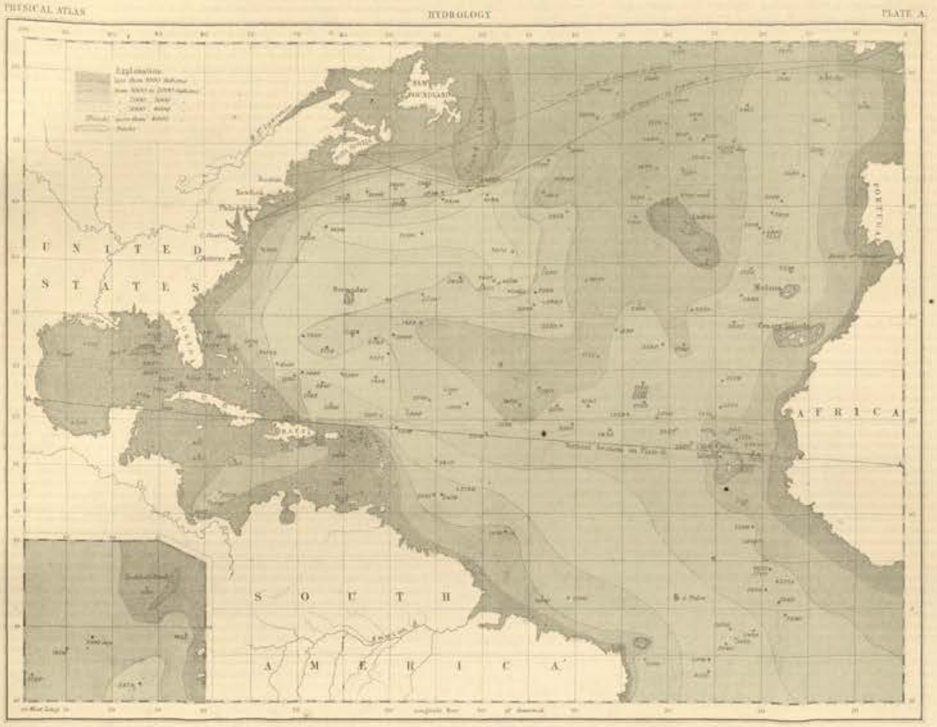
THE BASIN OF THE ATLANTIC OCEAN,

ITS SHAPE AND BOTTOM.

This Plate is believed to give, with some approaches to accuracy, the shape of the basin which holds the waters of the North Atlantic Ocean, especially of that part of it which lies between the equator and a line from Cape Race, in Newfoundland, to Rockall, off the west coast of Ireland. The little circles over the figures, on the Plate, which represent the soundings, are intended to show, by their centre, with as much accuracy as the scale on which the Plate is constructed will admit, the latitude and longitude of the soundings. Those soundings which have, above the figures denoting them, a dash, with a dot over the middle of it, indicate that, at the depth expressed by the figures below, in fathoms of 6 feet to the fathom, there was "no bottom," according to the official report. The Chart is stippled with four shades. The shaded bands represent the one, two, three, and four thousand fathom steppes at the bottom of the Atlantic; that is, from the shore to the outer edge of the darkest shading the sea is less than 1000 fathoms, or 6000 feet deep. Within the space covered by the next deepest shading it is less than 2000 fathoms, or 12,000 feet deep; within the space covered by the third deepest shading it is between 2000 fathoms or 12,000 feet, and 3000 fathoms or 18,000 feet deep. The lightest shading is intended to show where the ocean is more than 3000 fathoms, or 18,000 feet, but less than 4000 fathoms, or 24,000 feet deep; and where there is no shading, in the blank space south of Nova Scotia and the Grand Bank of Newfoundland, it is intended to show a district where very deep water has been reported, but from casts of the deep-sea lead which, upon discussion, do not appear satisfactory. With this explanation, it will be perceived that the tracing of these various curves is in many places, and for the most part, matter of conjecture. They can be accurately drawn only where soundings have been actually obtained, and the Plate itself shows, therefore, what part of the curves are drawn from data and what by conjecture. One of the conclusions which it would seem that we are authorised to draw from thus presenting the results, so far obtained, is this, viz., that if there be any part of the Atlantic Ocean, between the Banks of Newfoundland and the equator more than 4000 fathoms deep, it is probably no great part in comparison to the whole. Another feature exhibited, as to the shape of the steppes in this great oceanic basin, is worthy of notice. There seems to be, as we travel south from the Grand Banks of Newfoundland, a precipitous ledge, or what sailors would call a "jumping-off place," right under the Gulf Stream. They are shelving from the north; that is, as you approach them from the north you gradually lessen your water until you reach the shoalest part, and then there is a sudden jump off into deep water. The conflict between the two currents is sharp as they round this cape—the Gulf Stream is the stronger. Its course is interfered with by this cape, and shoal, and counter-current, and in a similar way it is encroached upon by the Grand Banks and the cold current from the north. Does not this view give grounds for the conjecture, that the deposits which form the Grand Banks come from the north?—(Maury.)

CHART OF THE BASIN OF THE ATLANTIC OCEAN,

ACCORDING TO THE DEEP-SEA SOUNDINGS MADE BY THE AMERICAN NAVY UNDER THE DIRECTION OF LIEUTENANT MAURY.



VERTICAL SECTION OF THE NORTH ATLANTIC OCEAN,

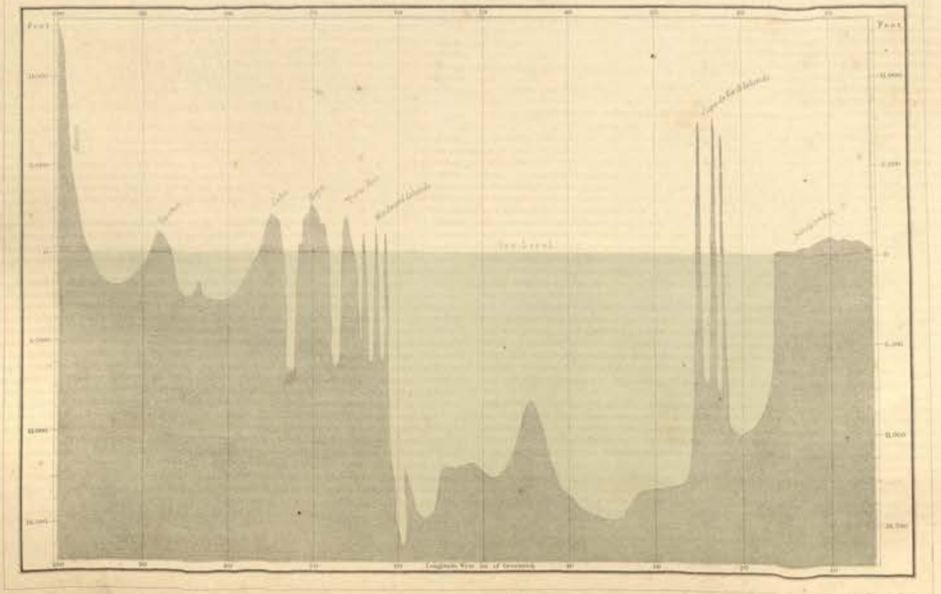
ON THE LINE MARKED A. B. ON THE CHART ABOVE.

This is a profile view of the basin of the Atlantic. It commences from the volcanic ranges in Mexico, latitude 20½°, and, pursuing a straight line, terminates on the shores of Western Africa, latitude 18° north.

This section confirms the conjecture which the deep-sea soundings suggested soon after they were commenced, viz., that the bottom of the sea is probably much more rugged and abrupt than the surface of the dry land. Reasons why such should be the case are obvious: On the land, the winds, the rains, and rivers are always abrading, drifting, and washing down the high places and filling up the low; these agents are not felt at all, or, if felt, felt but feebly at the bottom of the deep sea.

On the dry land, frosts and the force of gravity are great levellers. At the bottom of the deep sea no frosts are felt, and the difference of the force of gravity, operating upon a rock at the bottom of the sea, and upon the top of a mountain, is as the difference in weight between air and water.

This section, and the Chart to which it refers, also confirm the general law, that, on receding from the shores of continents, the submarine ground descends with a gradual slope; but on reaching a certain distance, more or less in different oceans, the slopes change suddenly, and the depths increase so rapidly, that, at a comparatively small distance, they are tenfold greater than near the shore. Thus, in the lines of soundings traced perpendicularly to the coast, at different points between New Jersey and Block Island, United States, under the direction of Professor A. D. Bache, all the sections show the ground descending gently to the distance of 80 or 100 miles from the shore, where the depth is not more than 400 or 500 feet, but at a distance of 10 miles it descends to 3000 or 4000 feet; the first part showing a declivity of about 5 feet per mile, while the second is more than 400 feet.



CURRENTS OF THE ATLANTIC.

The Gulf Stream.[1]—This, the most remarkable and best known of the ocean currents, has its origin in the Gulf of Mexico, whence it issues by the Strait of Florida, and, like a mighty river, with a current more rapid than that of the Mississippi or the Amazon, stretches across the ocean—one portion in a north-easterly direction, passing Norway and Spitzbergen to its outlet in the Arctic Sea; the other passing south-east towards Madeira, along the shores of Marocco, where its indraught has occasioned many shipwrecks. The Gulf Stream takes this direction in accordance with the laws of the diurnal rotation of the globe, aided by prevailing winds, and not, as has been inferred, because its waters are turned to the east by the coasts of the United States and the shoals of Nantucket. According to these physical laws, the current takes the most direct course that nature will permit it to reach its destination, and this course is nearly that of a great circle. As it leaves the coasts of the United States, it begins to vary its position according to the seasons; the limit of its northern edge, as it passes the meridian of Cape Race, being in winter about latitude 40° or 41°, and in September, when the sea is hottest, about latitude 45° or 46°. Its head is confined between the shoals of the Bahama Islands and North and South Carolina; but that part of it which stretches over toward the Grand Banks of Newfoundland is, as the temperature of the water of the ocean changes, first pressed down towards the south, and then again up toward the north, according to the season of the year. Thus in winter the volume of cold water on the American side of the stream is greatly increased, and presses the warmer waters of the Gulf Stream further to the south, while in September the temperature of these cold waters is modified; they do not extend so far, and then the warmer waters in turn press them back, and so a pendulum-like motion is produced. The water of this current is of a deep indigo blue colour, and so distinctly marked that its junction with the common sea-water may be traced by the eye. Its temperature off Cape Hatteras, and even as far north as the Grand Banks of Newfoundland, is higher by 20° or 30° than that of the adjoining ocean. As a rule, the hottest water of the Gulf Stream is at or near the surface; and as the deep-sea thermometer is sent down, it shows that this water, though still far warmer than the water on either side, at corresponding depths, gradually becomes less and less warm, until the bottom of the current is reached; for there is reason to believe that the warm water of the Gulf Stream nowhere touches the bottom of the sea, but that there is everywhere a cushion of cool water between it and the solid part of the earth's crust. Recent observations of the United States Coast Survey indicate that there are in the Gulf Stream threads of warmer, separated by streaks of cooler water. The hottest water is the highest; and as it rises to the top, it is cooled both by evaporation and exposure, when the surface is replenished by hot water from below. Thus, in a winter day, the waters on the surface, off Cape Hatteras, have been observed to be 80°, while at the depth of 500 fathoms (3000 feet) the thermometer has stood at 57°. One hundred and twenty miles from this, off the Capes of Virginia, it stands 1° or 2° less at the surface, while all below is cooler. In other words, the stratum of water at 57°, which was 3000 feet below the surface off Hatteras, has in a course of 120 or 130 miles, in a horizontal direction, ascended vertically 600 feet—that is, this stratum has run up-hill with an ascent of 5 or 6 feet to the mile.

The maximum temperature of the Gulf Stream is 86°, or about 9° above the ocean temperature due to the latitude. Increasing in its latitude 10°, it loses but 2° of temperature; and, after having run 3000 miles towards the north, it still preserves, even in winter, the heat of summer. With this temperature it crosses the 40th degree of north latitude, and there, overflowing its liquid banks, it spreads itself out for thousands of square leagues over the cold waters around, and covers the ocean with a mantle of warmth that serves so much to mitigate in Europe the rigours of winter. Moving now more slowly, but dispensing its genial influences more freely, it finally meets the British Islands. By these it is divided, one part going into the polar basin of Spitzbergen, the other entering the Bay of Biscay, but each with a warmth considerably above the ocean temperature. Such an immense volume of heated water cannot fail to carry with it beyond the seas a mild and moist atmosphere. And this it is which so much softens climate there.

We know not, except approximately in one or two places, what the depth or the under temperature of the Gulf Stream may be; but assuming the temperature and velocity at the depth of 200 fathoms to be those of the surface, and taking the well-known difference between the capacity of air and of water for specific heat as the argument, a simple calculation will show that the quantity of heat discharged over the Atlantic, from the waters of the Gulf Stream in a winter's day, would be sufficient to raise the whole column of atmosphere that rests upon France and the British Islands from the freezing point to summer heat.

Every westerly wind that blows crosses the stream on its way to Europe, and carries with it a portion of this heat to temper there the northern winds of winter. It is the influence of this stream upon climate that makes Erin the "Emerald Isle of the sea," and that clothes the shores of Albion in evergreen robes; while in the same latitude, on the American side, the coasts of Labrador are fast bound in fetters of ice. In a valuable paper on Currents,[2] Mr Redfield states, that in 1831 the harbour of St John's, Newfoundland, was closed with ice as late as the month of June; yet who ever heard of the port of Liverpool, on the other side, though 2° further north, being closed with ice even in the dead of winter?

The isothermal lines of 60°, 50°, &c. (see Meteorology, Plate 18), starting off from the parallel of 40° near the coasts of the United States, run off in a north-eastwardly direction, showing the same oceanic temperature on the European side of the Atlantic in latitude 55° or 60° that prevails on the American side in latitude 40°. The ponds in the Orkneys (latitude near 60°) are not frozen in winter. The people there owe their soft climate to this grand heating apparatus, for drift-wood from the West Indies is occasionally cast ashore there by the Gulf Stream. Nor do the beneficial influences of this Stream upon climate end here. The West Indian Archipelago is encompassed on one side by its chain of islands, and on the other by the Cordilleras of the Andes, contracting with the Isthmus of Darien, and stretching themselves out over the plains of Central America and Mexico. Beginning on the summit of this range, we leave the regions of perpetual snow, and descend first into the *tierra templada*, and then into the *tierra caliente*, or burning land. Descending still lower, we reach both the level and the surface of the Mexican Sea, where, were it not for this beautiful and benign system of aqueous circulation, the peculiar features of the surrounding country assure us we should have the hottest, if not the most pestilential climate in the world. As the waters in these two caldrons become heated, they are borne off by the Gulf Stream, and are replaced by the cooler currents through the Caribbean Sea; the surface-water, as it enters here, being 3° or 4°, and that in depth 40°,[3] cooler than when it escapes from the Gulf. Taking only this difference in surface temperature as an index of the heat accumulated there, it can be shown by calculation that "the quantity of specific heat daily carried off by the Gulf Stream from those regions, and discharged over the Atlantic, is sufficient to raise mountains of iron from zero to the melting-point, and to keep in flow from them a molten stream of metal greater in volume than the waters daily discharged from the Mississippi River."

At the depth of 240 fathoms, the temperature of the currents setting into the Caribbean Sea has been found as low as 48°, while that of the surface was 85°. Another cast with 386 fathoms gave 43° below against 83° at the surface. The hurricanes of those regions agitate the sea to great depths; that which occurred in 1780 tore rocks up from the bottom in seven fathoms, and cast them on shore. They, therefore, cannot fail to bring to the surface portions of the cooler water below.

At the very bottom of the Gulf Stream, when its surface-temperature was 80°, the deep-sea thermometer of the Coast Survey has recorded temperatures as low as 38° Fahrenheit.

These cold waters doubtless come down from the north to replace the warm water sent through the Gulf Stream to moderate the cold of Spitzbergen; for within the Arctic Circle, the temperature at corresponding depths off the shores of that island is only one degree colder than in the Caribbean Sea, while on the coasts of Labrador the temperature in depth is said to be 25°, or 7° below the melting-point of fresh water. Captain Scoresby relates, that on the coast of Greenland, in latitude 72°, the temperature of the air was 42°; of the water, 34°; and 29° at the depth of 118 fathoms. He there found a current setting to the south, and bearing with it this extremely cold water, with vast numbers of icebergs, whose centres, perhaps, were far below zero. It would be curious to ascertain the routes of these under-currents on their way to the tropical regions, which they are intended to cool. One has been found at the equator 200 miles broad, and 23° colder than the surface-water. Unless the land or shoals intervene, it no doubt comes down in a spiral curve approaching the great circle.

Perhaps the best indication as to these cold currents may be derived from the fish of the sea. The whales first pointed out the existence of the Gulf Stream by avoiding its warm waters. Along the coasts of the United States, all those delicate animals and marine productions which delight in warmer waters are wanting; thus indicating by their absence the cold current from the north now known to exist there. In the genial warmth of the sea, about the Bermudas on one hand, and Africa on the other, we find in great abundance those delicate shellfish and coral formations which are altogether wanting in the same latitudes along the shores of South Carolina.

The same obtains on the west coast of South America, for there the cold current almost reaches the equator before the first sprig of coral is found to grow. A few years ago, great numbers of bonita and albercore—tropical fish—following the Gulf Stream, entered the English Channel, and alarmed the fishermen of Cornwall and Devonshire by the havoc which they created among the pilchards there.

It may well be questioned if the cities and towns on the Atlantic shores of the United States do not owe their excellent fish-markets, as well as the watering-places their refreshing sea-bathing in summer, to this stream of cold water. The temperature of the Mediterranean is 4° or 5° above the ocean temperature of the same latitude, and the fish there are very indifferent. On the other hand, the temperature along the coast of the United States is several degrees below that of the ocean, and from Maine to Florida the markets are supplied with the most excellent of fish. The "sheep's head," so much esteemed in Virginia and the Carolinas, when taken on the warm coral banks of the Bahamas loses its flavour, and is held in no esteem. The same is the case with other fish. When taken in the cold water off that coast, they have a delicious flavour, and are highly esteemed; but when taken in the warm water on the other edge of the Gulf Stream, though but a few miles distant, their flesh is soft and unfit for the table. The temperature of the water at the Balize reaches 90°. The fish taken there are not to be compared with those of the same latitude in this cold stream. New Orleans, therefore, resorts to the cool waters on the Florida coast for her choicest fish. The same is the case in the Pacific. A current of cold water from the south sweeps the shores of Chile, Peru, and Colombia, and reaches the Galapagos Islands under the line. Throughout this whole distance the world does not afford a more abundant or excellent supply of fish. Yet out in the Pacific, at the Society Islands, where coral abounds, and the water preserves a higher temperature, the fish, though they vie in gorgeousness of colouring with the birds, and plants, and insects of the tropics, are held in no esteem as an article of food. The few facts which we have collected bearing upon the subject, seem to suggest it as a point of inquiry to be made, whether the habitat of certain fish does not indicate the temperature of the water; and whether these cold and warm currents of the ocean do not constitute the great highways through which migratory fishes travel from one region to another.

Navigators often meet with vast numbers of young sea-nettles (*Medusæ*) drifting along with the Gulf Stream. Two or three years ago, an intelligent sea-captain fell in with such a "school of young sea-nettles as had never before been heard of." The sea was covered with them for many leagues, and they were so thick as completely to cover it. These medusæ are known to constitute the principal food of the whale: now the Azores or Western Islands is the great place of resort for whales; and thus "the Gulf of Mexico is the harvest-field, and the Gulf Stream the gleaner which collects the fruitage planted there, and conveys it thousands of miles off to the hungry whale at sea." The sea, then, has its climates as well as the land. They both change with the latitude; but one varies with the elevation above, and the other with the depression below, the sea-level. Each is regulated by circulation; but the regulators are, on the one hand, winds—on the other, currents. The Gulf Stream has a vast influence on the weather in the North Atlantic. The most furious gales of wind sweep along with it; and the fogs of Newfoundland, which so much endanger navigation in winter, doubtless owe their existence to the presence in that cold sea of immense volumes of warm water brought by the Gulf Stream. With such an element of atmospherical disturbance in its bosom, storms of the most violent kind might be expected to accompany its course; and accordingly the most terrific that rage on the ocean have been known to spend their fury in and near its borders. (See Table of Hurricanes, p. 62.) Several years ago, the British Admiralty set on foot inquiries as to the cause of the storms which so often rage, with disastrous effects to navigation, in certain parts of the Atlantic; and the result of the investigation was, that they are occasioned by the irregularity between the temperature of the Gulf Stream and of the neighbouring regions, both in the air and water. The habitual dampness of the climate of the British Islands (especially on the west coasts), when westerly winds prevail, and the occasional dampness of that along the Atlantic coasts of the United States during easterly winds, is attributable to the Gulf Stream. The clouds are loaded with vapours gathered from its warm and smoking waters, and it carries the temperature of summer, even in the dead of winter, as far north as the Grand Banks of Newfoundland. The influence of the Gulf Stream on commerce and navigation was formerly greater than it is now, simply because ships are faster, instruments better, and navigators more skilful than they formerly were. Though crossed and recrossed for upwards of three centuries, navigators never thought of using it as a means of determining longitude, and giving warning of approach to the American shores. Dr Franklin was the first to suggest this use of it, when in London in 1770, on occasion of a memorial being presented from the Board of Customs of Boston to the Lords of the Treasury, stating that Falmouth packets were generally a fortnight longer to Boston than common traders were from London to Providence, Rhode Island. Franklin consulted Captain Folger, a Nantucket whaler, then also in London, who explained that the difference arose from the circumstance that the Rhode Island captains were acquainted with the Gulf Stream, while those of the English packets were not. The latter kept in it, and were set back 60 or 70 miles a-day, while the former avoided it altogether. The captain had become acquainted with it from the circumstance that whales were found on both sides, but never in the stream. No part of the world presents a more difficult or dangerous navigation than the approaches to the northern shores of the United States, in winter. Before the warmth of the Gulf Stream was known, a voyage at this season from Europe to New England, New York, and even to the capes of the Delaware or Chesapeake, was many times more trying, difficult, and dangerous than it now is. "In making this part of the coast, vessels are frequently met by snow-storms and gales which mock the seaman's strength and set at naught his skill. In a little while his bark becomes a mass of ice, and, with her crew frosted and helpless, she remains obedient only to her helm, and is kept away from the Gulf Stream. After a few hours' run she reaches its edge, and, almost at the next bound, passes from the midst of winter into a sea at summer heat, causing the ice to disappear from her apparel." Many ships annually founder in these gales; and there are many instances in which vessels bound to Norfolk or Baltimore, with their crews enervated in tropical climates, have encountered, as far south as the Capes of Virginia, snow-storms that have driven them back into the Gulf Stream again and again, and have kept them out for forty, fifty, and even sixty days, trying to make an anchorage. Yet the presence of the warm waters of the Gulf Stream, with their summer heat in mid-winter, off the shores of New England, is a great boon to navigation. At this season of the year especially, the number of wrecks and the consequent loss of life along the Atlantic sea-front is frightful. The month's average of wrecks has been as high as three a-day. Before the temperature of the Gulf Stream was known, vessels in distress knew of no place of refuge short of the West Indies; and it was no uncommon occurrence for vessels to go there and wait the return of spring before attempting another approach to the coasts. Franklin's discovery of the temperature of the Gulf Stream was therefore regarded as of great importance, not only because it afforded to the frosted mariner in winter a convenient refuge from the snow-storm, but because it served as an excellent landmark or beacon for the North American coast in all weathers. The immediate effect of this discovery was to render the northern ports as accessible in winter as in summer. Before Franklin's discovery, the Gulf Stream was altogether insidious in its effects. By it vessels were often, unawares, drifted many miles out of their course. The discovery of its high temperature assured the navigator of the presence of a current of surpassing velocity, and which, now turned to a certain account, would hasten, as it had formerly retarded, his voyage in a wonderful degree. Since the application of the thermometer to the Gulf Stream, the average passage of a sailing-vessel from England to the United States, as previously noticed, has been reduced from upwards of eight weeks to a little more than four. A table of the velocity of the Gulf Stream, in different parts of its course, will be found in the north-west corner of the Chart. From this it appears that the average rate from the Narrows at Bemini Island, to latitude 31° north, is sixty-three miles in twenty-four hours. In May 1804, Humboldt observed, in latitude 26° and 27°, a velocity of eighty miles in twenty-four hours, or five feet per second, although at the time the north wind blew with great violence. At the end of the Gulf of Florida, in the parallel of Cape Canaveral, its rapidity resembles that of a torrent, and is sometimes five miles an hour (120 miles per day). The velocity decreases gradually in its progress towards the north-east. Between 65° and 66° west longitude, it runs fifty-five miles per day; and at 42° 30′ west (900 miles farther east), from thirty to thirty-five miles per day: it diminishes more rapidly after it bends to the south, and in the vicinity of the Azores it is not more than ten miles per day. Major Rennel calculates that the stream arrives from its source to the Azores Islands (3000 miles) in seventy-eight days, which gives an average rate of nearly thirty-eight miles per day.

Equatorial Current. This current has its origin in the warm water about the equator, between Africa and America; and, after receiving the waters of the Amazon and the Orinoco by the way, it flows into the Caribbean Sea, and thus becomes the feeder of the Gulf Stream. On crossing the equator, its course is parallel with the Guinea Current for more than 1000 miles; exhibiting the "remarkable phenomenon of parallel streams in contact with each other, flowing with great velocity in opposite directions, and having a difference of temperature of 10° or 12°. Thus, according as a vessel, intending to proceed along the coast in either direction, happens to be in the one or the other of these currents, her progress will be accelerated or retarded from forty to fifty miles per day." Proceeding on both sides of the equator to 22° west longitude, it sends off the *North-west Branch Current*, and then, declining gently to the south, it runs to within 300 miles of Cape St Roque, on the coast of Brazil, where it divides, the northern and principal part forming the *Guiana Current*, which enters the Caribbean Sea. The southern portion, flowing in the direction of the coast of South America, but at a considerable distance from it, forms the *Brazil Current*. The length of the Equatorial Current is, from the coast of Africa to Cape St Roque, 2500; or to its entrance into the Caribbean Sea, 4000 nautical miles. Its breadth, near the commencement, is 160 miles; opposite Cape Palmas, 360; and before dividing, it is at least 450 nautical miles. Its greatest velocity occurs in summer, and the least in winter. From 5° east to 10° west longitude, the average is from twenty-five to thirty miles per day. From 10° to 16° west, towards the end of June and beginning of July, it varies from forty-four to seventy-eight miles; between 16° and 23° west it amounts to from forty-five to sixty miles. The mean velocity may therefore be reckoned at thirty miles in twenty-four hours. Its average temperature is about 75° Fahrenheit.

The **Brazil Current**, forming, as noticed above, the southern branch of the Equatorial Current, from which it separates near Cape St Roque, has been greatly dreaded by navigators, on account of the difficulties which dull-sailing vessels falling to the leeward of St Roque have found in beating up against it; and from the circumstance of its being reported to have caused the loss of some English transports during the last century, by drawing them towards the coasts of Brazil. But the special investigations of Lieutenant Maury have led to the conviction that it is "neither a dangerous nor a constant current." It was stated to be dangerous to all vessels crossing the equator west of longitude 23° west; but Lieutenant Maury's researches "abundantly prove, that vessels which cross the equator 500 miles to the west of longitude 23° west, have no difficulty, on account of this current, in clearing that cape."[4] This current flows at a distance of from 250 to 300 miles from the shores of South America, and extends from six to seven degrees into the ocean. The space between it and the coast is occupied by other currents which follow the direction of the monsoons. It is crossed by the River La Plata, the muddy water of which is observable at a distance of upwards of 200 miles out at sea; but the river appears to have little effect in changing the direction of the current, since it may still be traced, though much weakened, to the Strait of Magalhaen.

The Guiana Current, the northern continuation of the Equatorial Current, runs along the low coast of Guiana to the Island of Trinidad. At the Equator it is crossed by the Amazon River, which, running with great violence, forms eddies and whirlpools. The waters of the river and the current do not mix, and the former are observable at a distance of 300 miles from its mouth. At the Island of Trinidad, the Orinoco pours an immense mass of water into the current, which, entering at a very acute angle, soon mixes with and considerably accelerates its course. The current enters the Caribbean Sea by the strait between the Islands of Trinidad and Martinique. Its velocity varies from ten to twenty-one and thirty-six miles per day at different parts of its course.

The Cape Horn Current flows constantly from the Antarctic and South Sea into the Atlantic Ocean, and is usually accompanied by westerly storms. Its general direction is east-north-east and north-east. On the eastern side of the continent it turns towards the north-east, and surrounds the Falkland Islands. In certain seasons it maintains its north-easterly course to the parallel of 49° or 48° south, when it turns more towards the east, and mixes, without doubt, although at an unknown distance, with the waters of the Southern Connecting Current. Krusenstern remarked a velocity of from twelve to fifteen miles per day off Tierra del Fuego. In longitude 74° 14′ west, latitude 57° south, Captain Wendt found it, on 23d December, amount to thirty-five miles per day; and on 23d March, in latitude 58° south, the observed velocity was at the rate of fifty-two miles per day. Between Cape Horn and Staaten Land, latitude 55° south, Captain Foster found it run towards the north 51° east, at the rate of fifty-six miles per day. According to Captain Fitzroy's observations, the velocity, in the vicinity of the coast, amounts to twenty-four miles per day. Its temperature is much lower than that of the adjacent ocean or the atmosphere; but the amount of this decrease is not yet ascertained.

Southern Connecting Current.—The part of the ocean occupied by this current is very imperfectly known, and it is doubtful whether it may be connected with the Brazil Current in the north. It flows east-south-east, and mingles its water with the Southern Atlantic and the Mozambique currents to form the recently discovered stream which flows into the Southern Ocean south of the Cape of Good Hope.

The North African and Guinea Current, originates in the sea opposite the coast of France, between Cape Clear in Ireland and Cape Finisterre in Spain. It flows in a south and south-easterly direction to Cape St Vincent, between which and Cape Cantin in Marocco, the whole mass of water, as far as 20° west longitude, sets into the Strait of Gibraltar. From Cape Cantin to Cape Bojador, it is directed more to the eastward, which direction is continued to Cape Blanco; but in the latter space it extends only from 150 to 180 miles from the land. At the Cape Verde Islands the current turns gradually towards the south, then, following the coast of Africa, it flows south-east and east-south-east, and, after passing Cape Mesurada, its course is due east into the Bight of Biafra, flowing in contact with the Equatorial Current. The breadth of this current varies with the season; opposite Cape Palmas, it has been found to extend to 180 miles. Its greatest velocity is during the season of south-west winds (June to September). Near the beginning of its course it runs at the rate of twelve miles per day; after passing Cape Mesurada, its rate is nearly fifty miles. Its temperature increases rapidly to the southward; and in the Gulf of Guinea, Colonel Sabine observed a temperature of 84° in mid channel, diminishing from 83° to 82° in its southern verge, where it is in contact with the colder water of the Equatorial Current, and 79° and 81½° on its northern side, in the proximity of the land.

Southern Atlantic Current.—This current is now ascertained to flow southwards along the west coast of Africa, where it passes south of the Cape of Good Hope and joins the Mozambique Current, forming a united stream of warm water flowing southwards into the Southern Ocean.

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[1] Chiefly from the recent researches of the American Marine, under the able and active superintendence of Lieutenant Maury. For further detail see his Sailing Directions, and the "Physical Geography of the Sea," 1855.

[2] American Journal of Science, vol. xlv., p. 293.

[3] Temperature of the Caribbean Sea (from the journals of Mr Dunsterville). Surface-temperature, 83° September; 84° July; 85°-86½° Mosquito Coast. Temperature in depth, 48°, 240 fathoms; 43°, 386 fathoms; 42°, 450 fathoms; 43°, 500 fathoms.

[4] Physical Geography of the Sea, p. 144.

Rennel's Current.—This current commences near Cape Finisterre, and running along the northern coast of Spain, turns to the north and north-west, along the west coast of France, and traverses the English and Irish Channels, touching the Scilly Isles on the eastern border; it then continues to Cape Clear, on the southern coast of Ireland, whence, entering the ocean, it turns to the south and south-east, rejoining the North African Current. Its velocity amounts, in certain winds, to twenty-four and twenty-eight miles per day.

The Arctic Current.—This current is understood to originate in the masses of ice which surround the North Pole, whence it runs along the eastern shores of Greenland past Cape Farewell, and, continuing its southward course, it meets, in about latitude 50°, the *Hudson Bay Current*. Arriving at the north end of Newfoundland, the united stream sends a branch through the Strait of Belle Isle, which joins the outfall of the St Lawrence, while the main stream passes between the great and outer Banks of Newfoundland, and meets the Gulf Stream between 43° and 50° west longitude. Here it divides, one portion (as is probable from the icebergs which are brought into its warm waters) passing under the Gulf Stream and flowing southward to the Caribbean Sea, which it enters as an under-current.[1] The other flowing south-west, past Nantucket Island, forms the United States *Counter Current*, which extends between the Gulf Stream and the coast to Cape Hatteras and Florida. The Arctic Current thus replaces the warm water sent through the Gulf Stream, and mitigates the climate of the countries of central America and the Gulf of Mexico. Captain Scoresby counted 500 icebergs setting out on the Arctic Current at one time. Such enormous masses of ice must bring with them immense quantities of stones and earth, which, being deposited at the edge of the Gulf Stream, probably led to the formation, or at least the extension, of the great Banks of Newfoundland. The dense fogs which, at Newfoundland, so often endanger navigation, may be accounted for by the meeting of the warm waters of the Gulf Stream with this cold current.

Track Bottles.—Bottles containing a statement of the position of the ship, and date of immersion when sent afloat on the ocean, serve to indicate the general direction of *surface* currents. It will be seen, from the direction of those in the Chart, that the waters of the Atlantic, south of 45° north latitude, have a tendency to move towards the Gulf of Mexico. Whether these bottles were cast in near the shores of Europe or in the middle of the ocean, they have generally been found among the West India Islands. On the contrary, those which were immersed on the north of latitude 45° were carried to the coasts of Europe. The surface waters of the North Atlantic and Davis Strait, driven by the prevailing winds, have a tendency to run in an easterly direction till, between the meridian of 30° and 40° west, they appear to spread in a fan-like form northward to Iceland, and southward to the Canary Islands. The following examples are marked on the Chart: "*Hecla*," Captain Parry—1. A bottle was thrown from H.M.S. Hecla, Captain Parry, in latitude 56° 36′ north, longitude 25° 45′ west, on 13th October 1820, and found on the south coast of Iceland on the 6th or 7th March 1821. This indicates the northerly drifts of the Atlantic Head during the winter season, and shows, that although in early summer the currents here are generally prevalent to the south and south-west, they have a contrary direction in the other parts of the year. 2. A bottle cast from H.M.S. Hecla, Captain Parry, in latitude 53° 13′ north, longitude 46° 55′ west, 16th June 1819, was found on the south-east shore of Teneriffe, 29th July 1821. The straight lines on the Chart can, of course, only show the *shortest* distance through which these have travelled, from the time they were thrown out till they were picked up, and can give no direct information as to the course of the currents or drifts by which they may have been propelled.

Temperature and Oceanic Warmth Equator.—The mean of all the observations instituted by Humboldt, show that the temperature of the surface of the Atlantic Ocean is invariably higher than the mean temperature of the atmosphere. In the warm zone of the North Atlantic, the maximum of the sea between latitude 16° 20′, and 11° north, was 72.50 to 78.44, whilst that of the air amounted to 71.6, and 77.18 to 77.9. Peron came to the same conclusion, and found no exception to the rule in the zone between latitude 49° north and 45° south. The same result appears also from the observations of Meyen, and of Captain Fitzroy.

The recorded temperature of the sea, as well as that of the atmosphere, is dependent on the season of the year and the hour of the day at which the observation is made. The depth of the sea has a great influence on the temperature of its surface; for the immense body of water contained in the ocean preserves its heat; whereas, a thin stratum of water very soon acquires the colder temperature of the surface. This was verified by the experiments of Dr John Davy, who, on approaching the land off Table Bay, Cape of Good Hope, from the westward, found the temperature of the sea reduced 2°; and the same observation was made on approaching the Island of Ceylon, although the bank of soundings does not extend far out from either of these places. In calm and settled weather, Dr Davy found that the temperature of the sea reached its maximum about one or two hours after noon, and its minimum about sunrise. Peron found the temperature of the sea at mid-day invariably somewhat lower than that of the atmosphere; at midnight it was invariably higher, whilst in the morning and evening it was equal. The temperature of the atmosphere, as well as that of the ocean, increases regularly on approaching the Caribbean Sea from the shores of Europe and Africa. It is well known that all inland seas have a higher temperature than the open ocean under equal parallels; and besides the effect of heat communicated from the surrounding countries, the high temperature of the Caribbean Sea is greatly owing to the currents of warm water which enter it from the hot zone of the North Atlantic.

The result of many observations made on board the vessels of the Prussian mercantile marine, show that the temperature increases 0° 45′ for every degree of longitude in approaching the Caribbean Sea from the meridian of 45° west.

The line of maximum temperature of the atmosphere in the Atlantic Ocean does not correspond with that of the Terrestrial Equator; and this is also the case in regard to the water—the line of greatest warmth of which is found to be invariably on the north side of the Equator, in latitude 3° 35′ north, and its mean temperature 82° 6′, as represented on the Chart.

Icebergs.—In the Chart we have marked the limits of floating masses of ice in May and June in the Northern Hemisphere,[2] and the positions in which some of these have been found in lower latitudes. Ice-fields and bergs assume an infinite variety of shapes and appearances, their formation being ascribed to the breaking up of the immense glaciers which, during the winter months, occupy the valleys of the Arctic regions. Some of these ice-fields have been met with upwards of 100 miles in length, with an average breadth of fifty miles, and a mean elevation of from four to six feet above the water; while ice-islands have been estimated to attain the elevation of 180 or 200 feet. These immense masses of ice cool the surrounding seas, and give to the winds which blow from them a harsh and chilling influence. The water is rendered sensibly colder to a distance of from forty to fifty miles around them, and in their vicinity the thermometer has been found to fall from 61° to 43° (Fahr.) In March and April, the spring months of the Northern Hemisphere, the Arctic or northern icebergs are usually observed in the North Atlantic Ocean to drift farther to the southward before they are dissolved than at any other time of the year. They have been found in the Gulf Stream as far south as latitude 40° 35′ rapidly dissolving with the heat of the current. On the 18th and 19th April, the steam-ship *Great Western* encountered a field of ice perhaps 100 miles in extent. The largest iceberg was three-quarters of a mile long, and the highest was 100 feet above the surface of the water. About 300 were seen by this vessel. The field-ice varied in thickness from two to four and a-half feet. The lowest temperature of the water was 25°, and of the air 28°. Some icebergs were met as low as latitude 42°. By different vessels the ice was encountered over an extent of seven degrees of latitude; that is, from 40° to 47° north. In May, extensive fields of ice were still encountered, often carrying plump seals in considerable numbers. Many vessels were injured, and several lost, by coming in contact with icebergs, or being encompassed by these floating fields—the probable fate of the steam-ship *President*.

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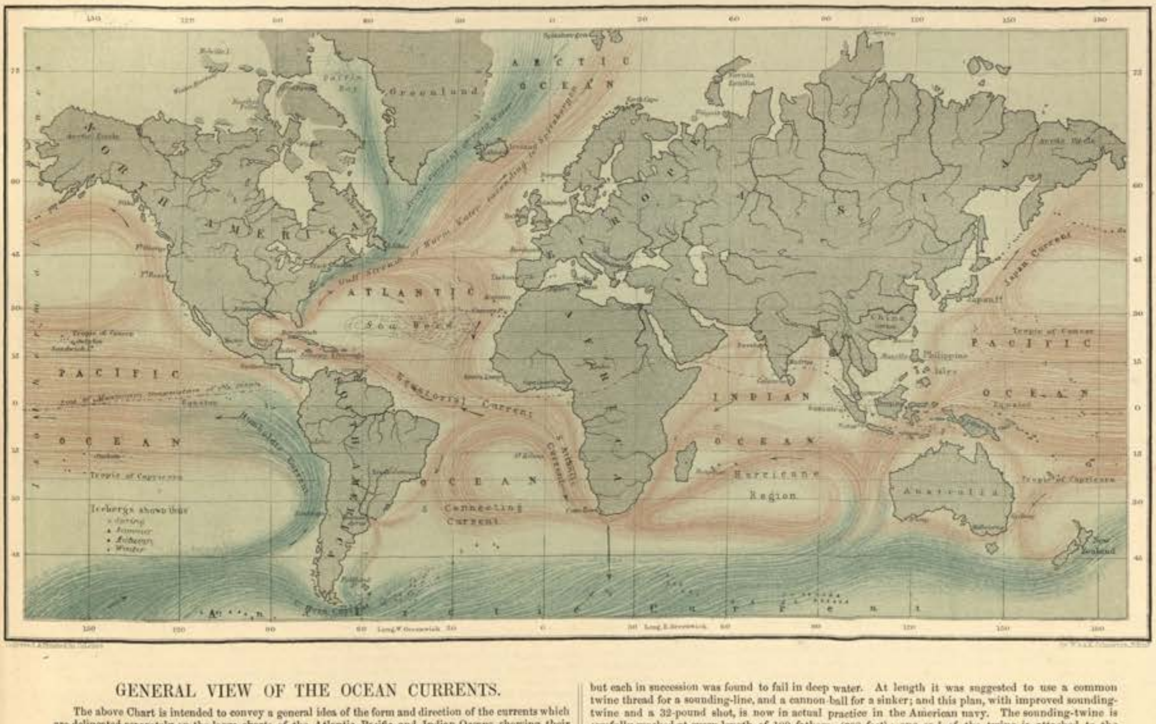
[1] The temperature of the Caribbean Sea at a little depth is, as noticed on the preceding page, far below the mean temperature of the air, and as cold as that of the sea at a corresponding depth off the shores of Spitzbergen.—See *American Journal of Science*, xxv., xlvii.

[2] For icebergs of the Southern Hemisphere see Chart below. See also Chart of the Arctic Basin, p. 48.

GENERAL SKETCH-CHART OF THE OCEANIC CURRENTS.



GENERAL VIEW OF THE OCEAN CURRENTS.

The above Chart is intended to convey a general idea of the form and direction of the currents which are delineated separately on the large charts of the Atlantic, Pacific, and Indian Oceans, showing their connection, and their extent as compared with the entire waters of the ocean. The thermal properties of the currents, as explained in the text, are here indicated by colours, the portions shaded red representing the warmer, and those shaded deep blue the colder currents; while the pale blue colour represents those portions of the ocean which are comparatively still, or where currents have not been observed. The oceanic warmth equator, or line of maximum temperature of the ocean, is here drawn in a continuous line (see the several Charts and the Tables, pp. 50, 52); and besides the icebergs shown in the Chart of the Atlantic near the Cape of Good Hope, this Chart shows the position of ice-fields drifted to low latitudes by the south polar currents, distinguishing those found in the different seasons of the year.

The currents of the ocean, which have been shown to exercise so great an influence on navigation, and on the climate of neighbouring coasts, originate in causes the relative influence of which is still imperfectly understood. Among these causes the principal are, the strength and the direction of prevailing winds; the changes in the density of sea-water at different depths and in different latitudes, occasioned by variations of temperature and evaporation, differences in the relative quantity of the saline contents of the sea producing a difference of specific gravity; the propagation of the tide-wave in its progress round the globe; and the horary variations of atmospheric pressure.

DEPTHS OF THE OCEAN.

It was long a prevalent opinion, founded on theoretical views of a physical law, that the depths of the sea must be nearly equal to the heights of the land; but this is now found to be erroneous. Till within a few years, soundings were made with silk threads or spun yarn, or with the common lead and line used in navigation. These attempts were made on the supposition that, when the lead reached the bottom, either a shock would be felt, or the line, becoming slack, would cease to run out; but the systematic series of experiments recently made by the officers of the American navy show that no reliance can be placed on this method of procedure when the depths reported exceed eight or ten thousand feet; for the shock caused by striking the bottom cannot be communicated through very great depths; and in general the under-currents of the deep sea have sufficient force to take the line out after the plummet has ceased to do so. Many ingenious and beautiful contrivances for deep-sea soundings were resorted to, but each in succession was found to fail in deep water. At length it was suggested to use a common twine thread for a sounding-line, and a cannon-ball for a sinker; and this plan, with improved sounding-twine and a 32-pound shot, is now in actual practice in the American navy. The sounding-twine is carefully marked at every length of 100 fathoms (600 feet): one end of the twine is attached to the cannon-ball; it is then thrown overboard, and allowed to run freely from the reel, which is made to turn easily. But unforeseen difficulties occurred: first the line, once started, never ceased to run out, and there was no means of knowing when, if ever, the shot reached the bottom; next it was found that the sounding-line, in going down, was subjected to a heavy strain: and it was therefore necessary that it should be of much stronger material. It was soon discovered, besides, that the soundings could not be made from the vessel with any certainty as to depth; consequently a boat had to be lowered, which the men with their oars kept from drifting while the sounding-shot was being dropped into the water. The running out of the line after the shot had reached the bottom could only be explained by the action of under-currents, several of which, running in different directions, might be operating upon it at the same time. To overcome these difficulties, attempts were made to ascertain a law of descent, which has at length been established, by timing the hundred-fathom marks as they successively go out—by always using a line of the same size and make, and a sinker of the same shape and weight. The mean of the experiments gives, for the sinker and twine used, two minutes twenty-one seconds, as the average time of descent from 400 to 500 fathoms; three minutes twenty-six seconds from 1000 to 1100 fathoms; four minutes twenty-nine seconds from 1800 to 1900 fathoms. By means of this law it can be calculated, very nearly, when the ball ceases to carry the line out, and when it begins to go out in obedience to the currents alone, for the latter carry it out at a uniform, but the former at a decreasing rate of motion. Previous to these more recent experiments, Lieutenant Walsh, of the U.S. navy, reported a cast of 34,000 feet without bottom; Lieutenant Berryman, also of the U.S. navy, reported no bottom at 39,000 feet; Captain Denham, of H.M.S. Herald, reported bottom in the South Atlantic at 46,000 feet; and Lieutenant Parker, of the U.S. navy, in attempting to sound near the same region, saw a line of 50,000 feet run out after his plummet, as though the bottom had not been reached. All these soundings are now believed to be exaggerated from the causes stated. The greatest depths at which the bottom of the sea has been reached with the plummet, by the improved methods of sounding, are in the North Atlantic Ocean; and the places where it has been fathomed do not show it to be deeper than 25,000 feet.[1]

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[1] Maury.

THE ARCTIC BASIN: ITS LIMITS, FEATURES, DRAINAGE, CURRENTS, WINDS, AND CLIMATES.

Without a correct knowledge of the polar segment of the Northern Hemisphere, the configuration of its lands and waters, its isothermal curves, its seasons, currents, and winds, and the cosmical or general laws which these obey, it is impossible to understand aright the corresponding phenomena in the adjoining milder latitudes. Neither the local climates of the north temperate belt, the circulation of its waters, the sources and qualities of its more remarkable winds, nor even the most important conditions which permit the distribution or limit the range of its plants and animals, can be adequately known until we study, in proper connection, the features and the physics of that polar cap in which all the meridional belts of the hemisphere find their common and influential centre.

Limits.—Disregarding arbitrary limits, the Arctic Basin, equivalent to the "Arctic Regions," includes not merely the north Polar Sea, but all those wide circumjacent lands which empty their drainage into that great ocean. Astronomically regarded, the Arctic Circle—the northern limit of sunshine in winter—is the boundary of the Arctic Regions; and geographically, the northern shores of America, Greenland, Europe, and Siberia define the Arctic Oceanic Basin; but we gain a truer insight into the physical and vital phenomena of the North, if we view as one great natural region all that larger hydrographic area which embraces the northward drainage of the arctic lands extending to the watershed which separates these slopes from the river-basins draining into the other seas. The Siberian division of this enormous region of converging and rotating waters includes the great rivers Obi, Yenessei, and Lena, and extends southward to latitude 50°, taking in all Northern Asia, from the Ourals to the Sea of Okhotsk; while the North American portion embraces the vast basins of the Mackenzie, Saskatchewan, and Hudson Bay, and reaches quite as far southward. Viewing Greenland and the countries bordering Behring Strait as portions of the Arctic Basin, it will be seen to include all the lands, excepting Northern Europe, which lie between the pole and the circle of 50° of north latitude. The broad zone of land thus bounded and draining into the Polar Sea has an area of about 5,000,000 square miles; the Polar Sea itself may be estimated to contain about 4,000,000 square miles. The river-systems of the Obi, Yenessei, Lena, and Kolyma, in Asia, with those of Mackenzie and Saskatchewan in America, alone cover a surface of more than 3,200,000 square miles, or equal to that of all Europe.

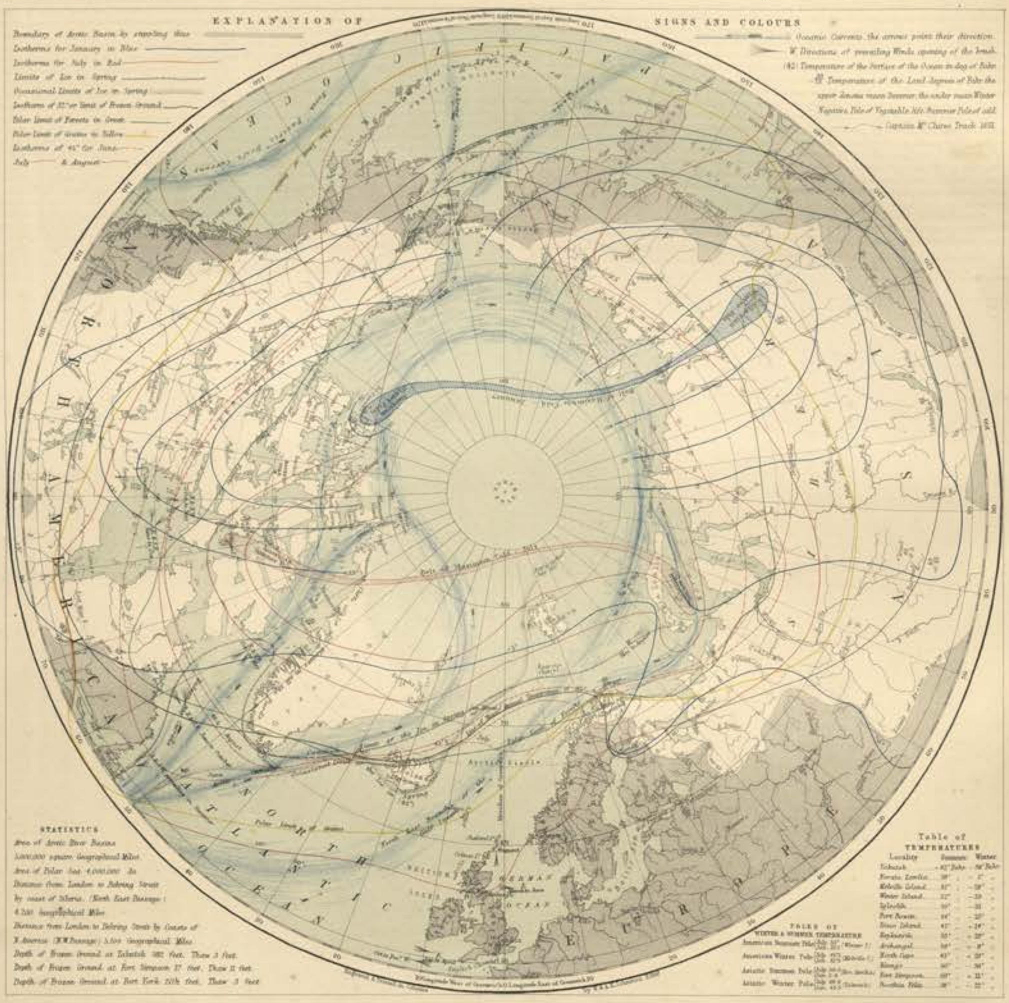
Configuration.—The Polar Sea, the central depression of the Arctic Basin, has an approximately circular outline coinciding roughly with the parallel of 73° north latitude—an important feature as connected with a circumpolar rotation of its waters. This sea has really but two outlets into the general ocean of the globe, one of which, Behring Strait, is less than 30 miles wide, and what is of more consequence, is very shallow, having less than 25 fathoms of water in its deepest channel. As an opening, therefore, it is almost null; so that the Polar Sea on this side is virtually land-locked. The other much wider, deeper outlet, is partially blocked by an immense belt of cliff-lined islands, from Iceland to the Parry group, the largest being Greenland. Many of the more mountainous of these have a height exceeding 3000 feet, and they are separated by commensurately deep straits traversed by strong currents; but these are so clogged with ice as to be only occasionally passable, and then to none but the most courageous navigators.

The sole practicable inlet to the Polar Sea is the wide channel between Spitzbergen or Iceland and the north-west coast of Europe. This is the broad highway for the north-east branch of the Gulf Stream. While north-eastern and north-western Arctic America possess a high and broken relief answering to indented shores, and an archipelago of high cliff-girt islands with deep channels, a large expanse of Arctic Asia consists of level table-lands and low plains fronting a shallow sea.

Drainage.—In the cold arctic regions the excess of precipitation over evaporation is greater than in the warmer zones, and this excess is derived from the humid south-west winds which for ever invade their border. But throughout a large portion of the year the precipitation does not flow off, but remains frozen on the surface, until the sudden arrival of summer sets the whole mass free; then, augmented by the summer rains, the entire annual accumulation pours off, during a few weeks, into the Polar Sea. The northward direction of all the great arctic rivers imparts peculiar power to the periodical breaking-up of the streams; for, getting into motion at their sources, while they are tightly ice-locked below, they flood their broad valleys and deltas with a vast expanse of drifting waters. Stupendous geological changes may be traced to these annual freshets, the magnitude of which can be conceived from the statements given of the areas of the river-systems. Draining a surface larger than that of the whole sea itself, these arctic rivers are really the prime movers of that great ocean-current which every summer drifts the polar ice south-westward down the coast of Greenland, down the west side of Baffin's Bay, and eastward against the Parry Islands.

Seasons and Climates.—If the Polar Regions consisted all of ocean, or all of level land, or if they included a circular sea entirely insulated from the currents and winds of other latitudes, the isotherms of summer and winter would be nearly regular circles arranged concentrically round the Pole; but from inequalities in the distribution of land and water, causing special currents and winds to invade the Polar Basin, these circumpolar isotherms depart widely from the circular form, and group themselves not around the pole, but about a long belt of maximum refrigeration, which has a wide annual oscillation from a westward winter to an eastward summer position. The blue and red lines of the map show the winter and summer isotherms, and likewise the two positions of the belts of maximum cold. This remarkable oscillation of the zone of cold, makes Melville Island and Boothia Felix the coldest winter localities in America, 8° or 10° colder in January than Winter Island and Igloolik, while in July they are from 5° to 7° warmer. It also causes the mouth of the Lena, in January, to be 40° or 50° colder than Novaia Zemlia, while it makes it 30° warmer in July.

Frozen Soil.—At Yakutsk, Siberia, latitude 62° north, the earth is frozen a depth of 382 feet, the temperature rising 1° for each 28° descent. In the same latitude, on Mackenzie River, the permanent freezing descends only 17 feet, but the mean annual temperature is here 25°, while at Yakutsk it is 11° lower. The thaw near Yakutsk, in summer, reaches 3½ feet, and at Fort Simpson, on the Mackenzie, 11 feet, but at Novaia Zemlia and Winter Island—the summer poles of cold—it penetrates to a very shallow depth. A less intensity of winter cold near Hudson Bay, compared with that at the Siberian pole of cold, causes the American frozen crust to be much the thinnest, though it extends quite as far south.


EXPLANATION OF SIGNS AND COLOURS
Boundary of Arctic Basin by stippling blue
Isotherms for January in Blue
Isotherms for July in Red
Limits of Ice in Spring
Occasional Limits of Ice in Spring
Isotherm of 32° or limit of Frozen Ground
Polar limit of Forests in Green
Polar Limit of Grains in Yellow
Isotherms of 41° for June, July & August
Oceanic Currents the arrows point their direction
Directions of prevailing Winds opening of the brush
(42) Temperature of the Surface of the Ocean in deg of Fahr
Temperature of the Land degrees of Fahr the upper denotes mean Summer the under mean Winter
Captain M'Clures Track 1851
STATISTICS
Area of Arctic River Basins 5,000,000 square Geographical Miles
Area of Polar Sea 4,000,000 do
Distance from London to Behring Strait by coast of Siberia (North East Passage) 6,240 Geographical Miles
Distance from London to Behring Strait by Coasts of N. America (N.W. Passage) 5,800 Geographical Miles
Depth of Frozen Ground at Yakutsk 382 feet. Thaw 3 feet.
Depth of Frozen Ground at Fort Simpson 17 feet. Thaw 11 feet
Depth of Frozen Ground at Fort York 20½ feet. Thaw 3 feet
POLES OF WINTER & SUMMER TEMPERATURE
American Summer Pole (Winter I.)
American Winter Pole (Melville I.)
Asiatic Summer Pole (Nov. Zemlia)
Asiatic Winter Pole (Yakutsk)
Table of TEMPERATURES
Locality Summer Winter
Yakutsk
Novaia Zemlia
Melville Island
Winter Island
Igloolik
Fort Reliance
Reykiavik
Archangel
North Cape
Fort Simpson
Boothia Felix
GERMAN OCEAN
ATLANTIC OCEAN
EUROPE
AMERICA

Winds and Currents.—These are the great carriers of heat and cold, the distributors of local climate. They are likewise the chief prime movers of the oceanic currents. Their general course in the Arctic Basin is therefore to be first considered.

Nearly all round the hemisphere south of and even within the Arctic Regions, south-west and west winds decidedly predominate, modified in the eastern half of Arctic America, and in Eastern Siberia and China, into north-west ones. Further within the Polar Basin, the natural or normal direction of the wind is from the north-east. In some districts, especially between the North Atlantic and the Polar Sea, there is an annual oscillation in the direction of the wind—a sort of monsoon, blowing from the north-east during the spring and early summer, and from the south-west during the rest of the year. The northward flowing-off above from the warm tropical zone, of heated and piled-up atmosphere brought over the equator by the north-east trade-wind, and its eastward momentum, derived from the excess of the earth's velocity at the Tropic over its velocity in higher latitudes, combine to make the general wind of the north temperate zone a south-west one, and near its north limit a nearly west wind. Viewed from the Pole this wind is a slow whirling of the air from right to left; whereas any stream of it, viewed from above the equator, has a rotation from left to right. But the convergence of the meridians, or contraction of the hemisphere in the higher latitudes, must conspire with the loss of northward momentum in the south-west wind from cooling, to restrain it from approaching very near the Pole. It is obvious that it cannot wind itself indefinitely towards the Pole in spirals or loxodromic curves, but, piled up and chilled, must swing round and flow southward as the polar wind. But in its progress toward the south, it rapidly lags to the westward, as it gets over faster-moving larger circles, and hence its prevailing direction is from the north-east; in some parts of the zone it penetrates to lower latitudes than in others, just as on certain meridians the opposite south-west wind which feeds it, approaches nearer to the Pole than elsewhere, and the two winds even hold sway alternately over the same district. In two sections of the sub-arctic and north temperate zone a north-west wind predominates, usurping the place of the normal north-east one. These north-west winds are probably prolongations of broad columns of the south-west breeze, which have completed in part or entirely the circuit of the Arctic Basin, and which, weighted by cold, and flowing down the continents, are powerfully deflected sideways toward the east by the less pressure of air in that quarter, arising from the warming action of the two Gulf Streams, the Mexican one on the east coast of America, the Japanese Current on the coast of Eastern Asia. Thus, instead of seeking the general equator of the globe, the cold arctic air of the eastern sides of the two continents turns aside and takes a near cut to the two local equators of warmth carried northward in the tepid currents which branch off from the tropical ocean. Following a stream of air through the north-east trade-wind of the Atlantic, the south-west wind of the Atlantic coast of North America, and the rotating west wind of the polar coasts of Siberia and America, and across the latter continent, where, rendered cold and dry, it flows obliquely the nearest way to the warmest sea, we perceive it to describe a great inverted sigmoid curve or left-handed figure 8, conforming to the sphere.

Possibly a part of the north-west wind of North America, and that too of Eastern Asia, may be fed directly from the general south-west wind by immediate deflection south-eastward across the continents, but the excessive coldness and dryness of these winds render this view not probable. By one or both of these routes, and perhaps by others not here traced, that admirable web of the threads of air is woven which we call the winds, distributing warmth and moisture to the production of special climates, and holding these to their appointed places on the hemisphere in their irresistible but soft embrace.

Arctic Currents.—As might be inferred from the prevalence of west winds round the coasts of the Polar Sea, there is a decided eastward rotation of its waters throughout its whole periphery. The north-east prolongation of the Gulf Stream sets into this sea, softening the boreal climates of Norway and Siberia, and sweeps round past Behring Strait, where it is augmented by a sort of second gulf stream of less volume and influence prolonged from the Japanese Current; thus enforced, it washes the arctic coast of America where, it preserves a lane of open water between the ice pack and the shore the greater part of the way from this inlet to the Parry Islands. There it streams through the great channels of this archipelago, and clogs them with its vast drift of ice, until it finally works its way out into the Atlantic through Baffin's Bay, and northward round Greenland, chilling as it flows southward, and then south-westward, all the north-eastern part of America with its ice-cold and ice-laden waters. The North Atlantic currents wheeling from left to right, these of the Polar Sea rotate with a reverse motion, reminding us of a spur wheel geared obliquely upon a driving wheel.

This normal eastward rotation of the circumpolar arctic waters appears to be hid or interrupted in the summer months in the region of Spitzbergen, by a surface ice-drift swept from the Siberian shores, and perhaps from more polar latitudes. It presses out into the Atlantic past Spitzbergen and Iceland, shoving eastward or flowing over the north-west edge of the insetting warmer current from the Gulf Stream. Hence, while in winter and spring the Polar Sea, seems easily penetrable by the broad channel between Spitzbergen and Europe, an almost impassable barrier of ice blocks the way during the summer months. It is thought that this annual movement of the drift ice is probably due to the sudden accession in summer of the continental waters flowing over the Polar Sea at the breaking-up of the great arctic rivers and the summer melting of the arctic snows. It is probably from the same causes that the ice, usually so tightly packed in the channels of the American arctic archipelago, sometimes suddenly gives way, and drifts in a body for vast distances towards or even into Baffin's Bay.[1]

Melville Sound, Lancaster Sound, and the other straits connected with Baffin's Bay, are all so engorged with ice by this eastward current, and are otherwise so difficult of navigation, from the winds and the extreme rigour of the summer season, that no passage to the westward by Arctic America has ever yet been achieved, after more than two hundred years of resolute and persevering research.—H. D. R.

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[1] These views regarding the movements of the winds and currents are fully confirmed by the observations of Dr Kane, in the second American expedition just returned, October 1855, in which he traced the north coast of Greenland far to the eastward, and reached latitude 82° 30′ to the N.W. of Smith Sound.

PLATE 13

PHYSICAL CHART OF THE INDIAN OCEAN.

I. INTRODUCTORY NOTE.

In the present edition of this Chart, considerable changes, the results of recent investigations, have been made on the direction of the ocean currents. The waters of the Indian Ocean are hotter than those of the Caribbean Sea, and the force of evaporation is much greater,—facts which lead to the inference that large currents of heated water have their origin here. One of these, escaping from the Strait of Malacca, and being joined by other warm streams from the Java and China seas, flows out into the Pacific, like another Gulf Stream, between the Philippines and the shores of Asia. Thence, nearly on the great circle route, it makes for the Aleutian Islands, and, after tempering the climates of those regions, loses itself in the sea towards the north-west coasts of America. The resemblance between the physical features of this current and the Gulf Stream of the Atlantic is very striking; and the Aleutian Islands are as noted for their fogs and mists as are the Grand Banks of Newfoundland. The Mozambique Current, which has its origin in the Red Sea, and joins the Cape Current, was till now believed to flow north along the west coast of Africa, to join the Great Equatorial Current of the Atlantic; but it has been ascertained that the current on the west coast flows south, and joins the Mozambique Current on the east, near the Cape of Good Hope, whence the united stream carries a body of warm water southward into the Southern Ocean; affording a new and unexpected example of beneficent arrangement and adaptation.[1] There are indications of another stream of warm water from the Indian Ocean flowing south between Africa and Australia, but further observations are necessary to point out its course. The effects which these currents produce in modifying climate may be estimated by comparing the difference of temperature of the ocean at different parts of its surface.[2] Recent observations have shown that the strongest rush of the north-west monsoon pursues a curvilinear path from the African to the Indian shore between lat. 5° and 20° north, expanding as it proceeds, and blowing with great fury on the coast between lat. 18° and 20°; while in an elliptical space between lat. 6° and 12° north and long. 60° and 71° east, light variable breezes, cloudless skies, and smooth water are commonly met with when the storm to the northward is at its height. It is in order to avoid the former and attain the latter of these regions that the steam-packets between Bombay and Aden steer their course during the rainy season, as shown in the chart.[3] In the construction of this chart, it was found necessary to alter the plan adopted in the other hydrographical charts of the Physical Atlas, by combining in one sheet the meteorological with the hydrographical conditions of this part of the ocean. The peculiar structure of the land surrounding this vast basin prevents such regularity of motion in the currents of the air and water as are apparent in the Atlantic and Pacific Oceans, and renders a constant reference to one kind of current necessary in explaining the other. Besides, the great importance of a knowledge of these aërial currents to the navigation of this much-frequented sea required that their limits should be delineated on a larger scale than was admissible in the general meteorological map of the currents of air; and although, on this account, this chart is more complicated than the others, it has been, by the use of signs and colours, rendered equally distinct. The Indian Ocean, bounded on the north by the countries of Asia, is divided from the Pacific, on the east, by the Indian Archipelago and Australia, and from the Atlantic, on the west, by Africa; while its southern limit is generally understood to be formed by a line drawn from the Cape of Good Hope to Bass Strait. Beyond these limits, on the north-east, the chart includes the regions of the China Sea and part of the Pacific Ocean, showing the extension of the monsoons and tyfoons.

II.—NAVIGATION OF THE INDIAN OCEAN.

Scientific seamanship has nowhere achieved more valuable triumphs than in the navigation of the Indian seas. The properly-trained seaman of the present day knows not only where to expect the existence of the prevailing winds at the different seasons, but how to turn them to the best advantage in prosecuting his voyage. "It is one of the chief points of a seaman's duty," says Captain Basil Hall,[4] "to know where to find a fair wind, and where to fall in with a favourable current. If," he says, "we take a globe, and trace on it the shortest route by sea to India, and then fancy that such must be the best course to follow, we shall be very much mistaken. And yet this is very much what our ancestors actually did, till time, and repeated trials, and multitudinous failures, gradually taught them where to seek for winds; and how to profit by them when found. According to this 'rule of thumb' sailing, a ship had only to steer from England to Madeira, pass the Canaries and Cape de Verde, and then to make a direct course to the Cape, and thence to India. On trial, however, this experiment always failed; for, on getting near the equator, a series of calms and squalls put a stop to this rectilinear scheme, and the mariners of old were then forced to toil along the coast of Africa, or were driven towards that of the Brazils, and very often they came back in utter helplessness." Having already[5] adverted to the routes usually followed in sailing from Europe to the Cape of Good Hope, we shall now point out the tracks thence to the coast of India, China, &c., as laid down in the chart.

From the Cape of Good Hope the voyager has the choice of several routes to the different parts of India, in the selection of one or other of which he must be guided by the season of the year, and the consequent direction of the monsoon winds. The most frequented of these are thus described by Krusenstern—1. The Inner or Mozambique Passage; 2. The Passage to the eastward of Madagascar; 3. Boscawen's Passage, 4. The Middle Passage; and 5. The Outer Passages.

1. *The Inner Passage*, which is the most direct, is through the Mozambique Channel, between Madagascar and the coast of Africa. This route is followed when the voyager leaves the Cape of Good Hope at such a period of the year as may lead him to calculate on arriving at the coast of India during the prevalence of the south-west monsoon. This passage is safest during the dry season, or from April to September, at which time the winds generally blow from south-south-east to the equator; and as the latitude is increased, they will be found to veer to the south-west. Following this course, Krusenstern left the Cape on 27th June 1797, crossed the line on 20th July, in longitude 46° 30′ east, passed the Island of Ceylon on the 2d, and anchored in Madras roads on the 4th August, having performed the voyage in 40 days.

2. *Passage to the eastward of Madagascar.* On this route the course is first easterly, and only so far to the north as is necessary, in order not to arrive within the region of the south-east trade wind before reaching longitude 52° east; if this wind were met with sooner, it might be difficult to proceed to the eastward, especially in the parallel of the south-east part of Madagascar, where the *Fort Dauphin winds* usually blow strong from the east-north-east. The track is now northerly till the voyager quits the south-east trade wind and enters the region of the south-west monsoon, by the assistance of which he may easily reach any part of India.

This passage is also chosen when the navigator expects to reach India during the south-west monsoon. Many voyagers, alarmed by the dangers in the Channel of Mozambique, choose this route instead of the inner one; and although the distance is greater, some ships make the passage in a shorter time; but Krusenstern thinks that, since these dangers have been carefully observed, the inner passage is to be preferred. Horsburgh[6] is of opinion, that in the months of August and September the passage east of Madagascar deserves the preference, and that from February to October the inner one might be chosen with advantage. He sailed from the English Channel on the 30th April 1802, and following this course, anchored in the roads of Bombay on the 30th July; thus completing the voyage from England to India in three months.

3. *Boscawen Passage*, so named from Admiral Boscawen, who in 1748 took this route with a fleet of 26 sail, and made a very quick passage to India. This track is to the northward of Mauritius, to the east of Galega Island, and west of Malha Bank. (See the Chart.) It is chosen chiefly by ships bound for Bombay, or the Malabar coast, which are so late in the season that they cannot expect to arrive there before the setting-in of the north-east monsoon. For ships which do not pass the Cape before the 1st September, this and the middle passage are the most advantageous, because, keeping far to the eastward, they will be nearer the coast to which they are destined at the approaching north-east monsoon.[7]

4. *The Middle Passage* is to the eastward of the former, having the Madagascar Archipelago to the west, and the Chagos Isles to the east. To enter this passage from the Cape of Good Hope, the course is due east till about longitude 67° or 68° east, when, crossing the parallels of 26° or 27°, and arriving within the region of the south-east trade wind, a true north course is proper, keeping in about longitude 66° east, as long as the south-east trade wind will serve. In the vicinity of the equator westerly winds are not infrequent; with the help of these, ships proceed to the northward. Beyond the equator, indeed, the favourable wind of the north-east monsoon sets in; but at the beginning of this monsoon the winds are oftener north-west than north-east, and, if not too strong, they are the more favourable for ships reaching the coast of Malabar, since the north-east monsoon arrives here 15 or 20 days later than on the southern coast of India.

5. *The Outer Passages*, or those to the eastward of the Chagos Isles. The most easterly of these is selected when ships are expected to arrive at Madras or in the Bay of Bengal during the full force of the north-east monsoon. In following this course, it is necessary to keep well to the eastward, in order that this wind may favour them in reaching the place of destination. The usual route is as follows: From the Cape of Good Hope the course is so far to the eastward that the south-east trade wind is sought to be met with first in longitude 80° or 85° east; it is then necessary to steer nearly due north, by which the longitude is a little amplified—that is, till the ship nears Cape Atchin (or Acheen), the northern point of Sumatra, without, however, coming in sight of it, because in its vicinity light north-west and westerly winds usually prevail; and besides, a strong current sets into the Strait of Malacca.

From the meridian of the north end of Sumatra, the navigator bound for Bengal shapes his course westward of the Nicobar and Andaman Islands to the Ganges.[8] If the destination of the ship be to the coast of Coromandel, it is not necessary to approach so near to Cape Acheen; it is sufficient to make the longitude of 90° east, whence, with a favourable wind, the course may be taken to Madras. From these examples, the difficulty of sailing from one part of India to another, during the prevailing monsoon, may be understood. A voyage from Calcutta to Madras, or from Madras to Bombay, may be made in a short time during the north-east, but not so during the south-west monsoon.

For example, a ship which sails from Madras to Bombay, during the prevalence of the latter wind, must increase the longitude at least 5°, and cross the equator far to the eastward; the south-east trade wind, which is often met with for the first time in latitude 10° or 12° south, must now be sought for, and with the assistance of this the voyager sails to the westward for about 20° or 25°, or until he reaches the meridian of 8° or 10° west of Bombay, when he crosses the equator for the second time, and comes again into the region of the south-west monsoon, which is now a favourable wind for sailing to the latter port. See on the chart the southern course from Bengal and Madras to Bombay in the south-west monsoon; and also the northern route, which can be followed only in the month of July. The voyage from Bombay to Madras, during the contrary or north-east monsoon, is beset with nearly as great difficulties as the former. The route from the Cape to Madras and Bengal during the south-west monsoon, as shown in the chart, enters the zone of the south-east trade wind in about the meridian of 80° east, whence the course is nearly due north to the point of destination. A comparison of these circuitous routes taken by sailing vessels with the tracks of steamers along the coasts, shows the great importance of steam navigation in the Indian Ocean.

ROUTES FROM THE CAPE OF GOOD HOPE TO CHINA, &c.

See on the chart the great route from Europe to China, during the south-west monsoon, on which we have given the track of the Netherlands ship *De Tromp*, from the Atlantic Ocean to Sunda Strait, with the position of the ship every day at noon. The best course for ships which have no occasion to touch at the Cape of Good Hope, is to pass it in about latitude 37° or 38° south, in order to avoid the strong westerly current of the Cape, and to take advantage of the easterly counter-current. From the meridian of the Cape to that of the Islands Amsterdam[9] and St Paul, the easterly course is usually run between the parallels of 36° and 40° south; latterly, the parallel of 37° has been preferred, because it is believed that there the winds are more steady than in higher latitudes. To insure the direct passage to China, a ship should be on the meridian of these islands not later than the 1st of July, so as to arrive in August.[10] From the meridian of Amsterdam Island the preferable course is to cross the meridian of 80° east, in latitude 38° south, and the meridian of 90° in about 33° south, in order that on arriving at latitude 20° the ship may be nearly on the meridian of the north-west point of Java, whence the route is by the westward of Christmas Island to Java Head. Through Sunda Strait the passage is either by Crocatoa Channel or Princes Strait. From the Strait of Sunda the course is nearly due north through the Strait of Banca or Gaspar into the China Sea, crossing the equator in the meridian of about 105° 30′ or 105° 40′ east.

From May till October the south-west, and from October till May the north-east, monsoon prevails in the China Sea. In the waters adjoining this sea the same winds occur north of the equator; but southward of the line, to about latitude 10° south, the direction of the wind is ten or twelve rhumbs, or points of the compass, different; that is to say, if on the north side of the equator, the north-east monsoon prevails; on the south it is west-north-west and west; and if the monsoon in the north is south-west, in the south it is east-south-east and east; hence, south of the equator these are called east and west monsoons. The currents in general follow the same direction as the winds, and since, as Krusenstern observes, "it is scarcely possible to overcome both, the navigator is obliged to seek, outside the China Sea, such winds and currents as will enable him, by a direct course, to reach the desired haven." The importance of an exact knowledge of the winds and currents of the Chinese and neighbouring seas may be conceived, says the learned admiral, when we reflect that, according to the course of the favourable monsoon, each month renders the adoption of a different route necessary. "I know several cases," he says, "in which ships were detained in these seas for a whole year, simply from a want of this knowledge; among others, I saw a ship which had been allowed to remain in Batavia too late in the season, make two ineffectual attempts to reach China by an easterly course; the natural consequence was that she was obliged to wait the return of the south-west monsoon, by which she lost an entire year." From Banca or Singapore Strait, the inner passage (west of the Paracels) is generally the most expeditious route in March, April, and May; but in June, when the south-west monsoon sets regularly in, the track by the Macclesfield Bank is preferable. Ships which arrive at Pulo Sapata later than September, find it very difficult to make a direct course to Canton, on account of the strong southerly currents and northerly winds which then prevail; experience has taught that, in these circumstances, the best course is to stretch to the eastward, where, along the coast of Luzon, changeable winds, often from the south-east, are met with in the month of October.

Eastern route to China during the north-east monsoon. (See the Chart.) This is the best course for ships bound for China direct, which leave the meridian of Amsterdam Island from the middle of September to December. The usual routes are, as shown on the chart, along the west coast of Australia, through some of the straits east of Java, and into the Pacific Ocean by Macassar Strait, the Molucca Passage, Gilolo Passage, or Dampier Strait, thence to the west of the Pelew Islands, and into the China Sea by the Strait of Formosa. Horsburgh gives the preference to the latter of these tracks, namely, that which passes to the west of Bouro, and enters the Pacific by Dampier Strait, thence to the west of the Pelew Islands, and into the China Sea by the Strait of Formosa. In the latter part of January or February, the best course from Amsterdam Island is not to enter the Pacific, but, passing through Macassar Strait, to steer along the west side of Mindanao and Luzon.

The Great Eastern Passage from Europe to China during the north-east monsoon. This route, which, as shown on the chart, is due east from the Cape of Good Hope to Australia, is the safest and most speedy for ships which leave the Cape late in the season. This track was followed by Captain Butler in the ship *Walpole*. He left the Cape at the end of September; on 31st October he saw the south-west point of Van Diemen's Land; on the 18th November, the Island of Annabon, one of the New Hebrides; on the 13th December he discovered a group of islands which he called "Brown's Range;" on the 21st he passed the Mariana Isles; on the 30th he entered the Strait of Formosa, and on the 1st January anchored in the Roads of Macao; thus performing the voyage in three months,—a period little beyond that usually required by the direct route during a favourable season, on which two months is reckoned a fair average from the Cape to Sunda Strait, and thence three weeks to the Canton River; the whole voyage from the English Channel to Canton being reckoned at from five to six months. Instead of passing to the south of Tasmania, ships often steer through Bass Strait. This route was followed by the frigate *Athenian*, with a convoy of ten Chinamen in 1804. They passed St Paul's on the 10th October, entered Bass Strait on the 29th, and, passing to the east of the New Hebrides, came in sight of the coast of China on the 28th December. Notwithstanding this example, and the saving of distance, Admiral Krusenstern gives the preference to the route by Van Diemen's Land, or Tasmania. In higher latitudes, westerly winds are more to be depended on, and the northerly winds and southerly currents, so frequently met with at the entrance to Bass Strait, are thus avoided.

Return Routes from China and India to Europe. The great object on this course is to get, as quickly as possible, into the region of the south-east trade wind, by the aid of which the voyage to the westward is speedily accomplished. In latitude 14° or 15° south this wind is generally fresh and steady, and it increases in strength towards the south-west. This is especially the case in the parallels of 18° or 20° south, where it often blows more powerfully than in lower latitudes; but in the months of March and April it is liable to interruptions, and sometimes entirely fails in the vicinity of the tropics.

In returning to the Cape of Good Hope from Bengal or the Strait of Malacca, ships must cross the equator in about latitude 89° east, and shape their course to the eastward of Rodriguez. From Madras, Ceylon, and the Malabar coast, the course is by the eastern or outer passage, cutting the equator to the eastward of 83° or 84° east, and steering towards Rodriguez and the neighbouring islands. During the north-east monsoon, the best course from the west coast of India, the Persian Gulf, and the Red Sea, to the Cape of Good Hope, is by the inner passage through the Channel of Mozambique, but this cannot be followed with advantage either very early or very late in the season, for then southerly winds are met with, which frequently cause delay and danger. Numerous examples of the return route from China are given on the chart, chiefly from recent voyages of the ships of the Royal Prussian Marine. It will be observed that the "high-way" from the Eastern Seas to Europe lies through the centre of the hurricane district, and hence these storms are, in general, only met with on the return voyage.

STEAM NAVIGATION IN THE INDIAN OCEAN.

The first steamer that ever went from England to India was the *Enterprise*, which left Falmouth 16th August 1825, and arrived at Calcutta on the 9th December, having been 145 days on the voyage. In the same year the *Diana* was built at Calcutta, and in 1827 employed in the Irrawady—the *Comet* of 24-horse power being employed in the Ganges. In 1828, the *Ganges* and *Irrawady* were built at Calcutta; and in 1829 the *Hugh Lindsay* was launched at Bombay, and in the end of the year performed the first trip to Suez, occupying 70 days in her going and returning voyages—5928 miles: she was only 41 days, however, under steam. It was not till 1838 that a sufficiency of steamers to maintain a communication regularly was provided by Government, and from this time the regular overland communication with Bombay dates. A contract was afterwards entered into with the Peninsular and Oriental Steam Navigation Company, to carry the mails direct to Calcutta; and since 1845 there have been mails nearly once a fortnight to and from Bombay. This portion of the packet service, hitherto under Government, not having been considered satisfactorily managed, was in 1853 transferred to the Peninsular and Oriental Steam Navigation Company, in whose hands are now the whole of our communications with India.

MAILS FROM LONDON—1846-53.							MAILS FROM BOMBAY—1846-53.						
Years.	Number of mails.	Days corrected for longitude.		Time of each voyage.			Years.	Number of mails.	Days corrected for longitude.		Time of each voyage.		
		days.	hours.	days.	hours.	min.			days.	hours.	days.	hours.	min.
1846	23	774	5	33	15	52	1846	23	824	19	35	2	
1847	25	832	19	33	7	23	1847	21	761	9	36	7	
1848	24	767		31	23		1848	19	643	23	33	21	
1849	23	720	5	31	7	31	1849	20	697	4	34	19	26
1850	25	763	19	30	13	34	1850	21	686	9	32	16	26
1851	24	779	*	32	20		1851	24	778	*	32	10	
1852	24	777		32	9		1852	25	801		32	1	
1853	23	768		34	4		1853	25	816		32	15	
	191	6178	48	32	12	30		178	6006	69	33	11	29

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[1] These important discoveries result from the valuable researches of Lieut. Maury. See Physical Geography of the Sea, 1855, pp. 136, 250. Naut. Mag. 1851, p. 384.

[2] The temperature is uniformly indicated on all the charts by Roman figures, enclosed within parentheses, in degrees and parts of Fahrenheit's scale.

[3] See Atlas of Skeleton Charts of the Arabian Sea and Bay of Bengal, by A. Keith Johnston and Dr Buist. Edin. 1854.

[4] Patchwork, vol. iii. p. 279.

[5] See Chart of Atlantic Ocean, and Notes.

[6] East India Directory, vol. i. p. 159, 5th edit. 1841, to which the reader is referred for the most complete and accurate instructions for navigating the eastern seas.

[7] Horsburgh, vol. i. p. 156.

[8] It was *formerly* thought that the passage to the eastward of these islands was the only secure route to Bengal during the north-east monsoon; but it is now well known that light north-west winds and southerly currents prevail along the Aracan coast at this season, which makes the passage along it to the northward very tedious.—*East India Directory*, i. 154.

[9] Amsterdam Island is laid down in the chart in latitude 38° 53′ south, longitude 77° 37′ east, from the surveys of the *Beagle*, Captain Stokes, who observes, "It is singular that though this island, which is almost a finger-post for ships bound from the Cape either to New Holland or India, has been so long known to all navigators of these seas, its true longitude should have been till now unascertained." In recent charts and tables it is placed in latitude 37° 52′, or 61 miles farther north.

[10] Captain Lynn, Edin. Cabinet Lib., China, vol. iii. p. 100.

* The hours of arrival in London are not given, so that in these cases the exact number of hours is not ascertained.

It will be seen from this, that from 1846 to 1850 the rate of our mail speed, both ways, was steadily improving; and that the mails take on an average a day longer to go to India than to come from it—were correction made for longitude, in reality above a day and a half. This is occasioned by the south-west monsoon, during which the outward mails occupy 27 days, the inward ones above 36. A table of the duties of the packets shows that, by the use of the best kind of ships, the time between Bombay and Suez might be shortened by three days at least. The following have been the average duties of the packets, as indicated by the times occupied by the mails from London :—

	Days.	hours.	min.		Days.	hours.	min.		Days.	hours.	min.
Feroze,	28	8	42	Sesostris,	31	19	0	Cleopatra,	33	19	0
Ajdaha,	29	4	36	Atalanta,	33	11	48	Acland,	33	22	25
Acbar,	27	19	0	Victoria,	35	16	34	Queen,	34	0	22
Mozuffer,	31	15	34	Semiramis,	32	19	0				

Within the last five years every third mail or so has been taken to India under 28 days; every fourth or fifth under 26; and two or three mails every year have gone out under 25 days. In August 1850 the mail arrived not much over 23 days, and in September the following year exactly in 24. On both these occasions the steamer had the benefit of the south-west monsoon, during which by much the swiftest passages are always made, fast-sailing vessels beating the fleetest steamers in the run north-westerly from Aden to Bombay, when they have full benefit of the breeze.

Distances in nautical miles by the Overland Route.—London to Marseille, *vid* Calais and Paris, 646; Marseille to Malta, 660; Malta to Alexandria, 856; Alexandria to Suez, 216; Suez to Aden, 1350; Aden to Bombay, 1650—*London to Bombay*, 5378 nautical, or 6138 statute miles. Southampton to Aden, 4604; Aden to Galle, 2150; Galle to Madras, 540; Madras to Calcutta, 730—*Southampton to Calcutta*, 8024. Galle to Pulo Penang, 1200; Penang to Singapore, 380; Singapore to Victoria, Hong Kong, 1440—*Southampton to Hong Kong*, 9774 miles.

The distance from Southampton to Calcutta by the Cape of Good Hope is calculated at 11,250 miles. The shortest estimated period of transit by the overland route is 35 days; but since the Cape route has been decided on, it is assumed that, by employing vessels capable of steaming at the rate of 15 or 17 knots an hour, the voyage, including stoppages, will not exceed 28 to 32 days. From Britain to Australia the course of post by sailing vessels is 250 to 257 days, without interval—by the Indian overland route it might be reduced to 169 days, with three days' interval; but this route involves three transhipments, with heavy charges to passengers, and is not suited for the conveyance of goods; besides, having to pass through the heart of Europe and Egypt, it is greatly dependent on our relations with foreign powers. The Panama route is held to be liable to similar objections. The committee on steam navigation have, therefore, decided on the Cape route to Australia, as affording a direct communication, without change of vessels—as being independent of other nations—and as being peculiarly adapted for merchandise. The steam-packet route from England to China, touching at Penang and Singapore, was established in 1845. In June 1851 the Peninsular and Oriental Steam Company established a regular line of communication between Calcutta and Hong Kong; and shortly after, the Government of the Netherlands East Indies started a mail packet between Singapore and Batavia. The route to Australia by Panama comprises three stages: 1st, Milford Haven to Navy Bay, on the Atlantic side of the Isthmus of Panama, 4552 miles; 2d, Across the Isthmus by railway to Panama on the Pacific side, 46 miles; 3d, Panama to Tahiti, 4488 miles; 4th, Tahiti to Sydney or Melbourne, about 3351 miles. Total from *England to Australia*, 12,437 *nautical* miles.

CURRENTS OF THE INDIAN OCEAN.

In the southern part of this sea the Equatorial Current connects the currents of the Pacific with those of the Atlantic Ocean, flowing from east to west at a rate varying with the different seasons. To the northward of the Island of Madagascar, where its extent is greatly circumscribed previous to its junction with the Mozambique Current, its rate of progress may be averaged at from 45 to 60 miles in 24 hours.

Mozambique Current.—A south-westerly current is observed to flow along the African coast towards the Channel of Mozambique during the whole year, which may be thus explained: The trade wind, which prevails in the South Indian Ocean, drives the water through the numerous groups of islands north-east of Madagascar towards the coast of Africa, whence it is repulsed and turned into the Channel of Mozambique, forming a constant southerly current, which is strongest during the prevalence of the south-east monsoon, and proportionally weak during the opposite or north-east monsoon. It is most rapid in the vicinity of the coast, where, at Cape Corrientes, as its name implies, the current is proverbially powerful. Its mean velocity varies from 18 to 28 miles in 24 hours; but this rate is greatly exceeded in particular circumstances; and Horsburgh quotes the extraordinary case of the ship *Northampton*, which reports a rate of 139 miles in 24 hours, or 5½ miles per hour,[1] a velocity which finds a parallel only in the maximum of the Gulf Stream. At Cape Padron the Mozambique Current passes into the Cape Current, and unites with the current flowing south along the west coast of Africa to send a stream of warm water into the Southern Ocean. To the eastward of the Mozambique Current, on the Madagascar side of the channel, there is generally a counter-current flowing north-eastwards.

On the northern side of the equator, the periodical winds, the land and sea breezes, and the general changes of the seasons, unite in producing currents which are as various as the courses of the winds by which they are produced, or the forms of the coasts along which they flow.

In the *Bay of Bengal* the currents are entirely dependent on the monsoons. During the south-west monsoon a northerly current (as shown by the arrows on the chart) flows along the Coromandel coast, beginning early in February, and increasing in strength till April and May, when the wind blows with the greatest constancy from the south. After this season it decreases in strength, but does not cease to flow till the middle of October, when it becomes very weak, and occasionally takes a southerly direction. In the middle of the bay the current, during March and April, is variable, and seldom strong. Between the coast of Coromandel and the Nicobar Islands, and between the latter and the entrance to the Malacca Strait, it often flows to the south-west, whilst in the northern part of the bay it has a southerly course in March, and in April its direction is frequently northerly. In the month of April the general north or north-easterly movement commences over the entire surface of the bay, and continues till the beginning or middle of October. During this period the velocity of the current depends on the strength of the monsoon wind; and its direction is very inconstant, since on the east side of the bay it sometimes flows south towards the Strait of Malacca. At the commencement of the north-east monsoon the system of counter-currents begins. On the Coromandel coast the southerly current is observed towards the middle of October, at the end of which, or early in November, it is very strong, running, in the vicinity of the land, often at the rate of two miles an hour. At a distance of two or three degrees from the coast, and in the middle of the bay, the south-west current regularly begins in the middle of October or November, when the north-east monsoon has attained a certain force; before this occurs it is variable, being sometimes south-south-west, and even north-west. In January the current decreases in strength on the coast of Coromandel and Orissa, and in February it almost entirely disappears in the vicinity of the land, as well as in the middle of the bay.

Nicobar Isles.—Between the Nicobar and Junk Ceylon Isles the current sets strong to the north-west and north during the north-east monsoon. On the coast of Aracan the prevailing direction of the current is to the south, although an opposite direction is sometimes observed.

Palks Strait.—During the north-east monsoon, the current frequently flows to the south-west and west, in Palks Strait, between the continent of India and the Island of Ceylon. In October and November a strong current flows south along the east coast of Ceylon, following the south coast westward to Point de Galle, and even to Colombo. Above Great Bassas it runs with a velocity of one and a-half to two miles per hour, and when the monsoon blows strong it is increased to two and a-half and three miles, but at other times it is comparatively weak. During the south-west monsoon these currents flow in an opposite direction, but their velocity is not nearly so great as in the former case, at least near the coast. The temperature of this current has been found to be 82° 4′ near Point de Galle.

Maldive Islands.—At the long chain of the Maldives the currents generally flow in an easterly direction, but local causes produce great deviations. When in June, July, and August, the south-west monsoon blows with full force in the district of the Northern Atolls, the current runs eastward with the wind; whilst late in June, July, and the early part of August, when the south-east trade wind approaches the equator in the southern part of the chain, the current often runs west-north-west. On the east side of the Northern Atolls the current flows generally to the west, in March and April; and in the space between the equator and latitude 4° or 5° south, it runs east-north-east. It extends a considerable distance on both sides of the meridian of these islands, with a velocity of from 40 to 50 miles per day. In the Equatorial Channel, and among the Southern Atolls, the current generally flows east in October, November, December, and January; while during the same season it flows to the west between the Maldives and Ceylon; and between latitude 3° and 5° north, in the meridian of Point de Galle, it has a velocity of from 30 to 35 miles per day, but this velocity decreases on approaching the equator.

Coast of Malabar.—In November the current is generally weak and uncertain on this coast, except in the vicinity of Anjenga, between which and Cape Comorin, a strong south-easterly current is sometimes observed. In January, on the contrary, the set of the current is northerly. From November to March, when the weather is generally fine, the current along the coast is scarcely perceptible; but between the Laccadives and the African coast it flows with the monsoon south-west, and has a velocity of from 8 to 12 miles per day. In March and April, when strong north-west winds prevail, there is generally a powerful south-east current along the Malabar coast, while among the Laccadives, and to the westward, the prevailing direction is south and south-west. In May the southerly current sets along the whole west coast of India, with a mean velocity of from 5 to 7 miles per day, which is increased on approaching Anjenga and Cape Comorin; but it sometimes happens that in May and June the current is hardly perceptible. When in these months the wind veers to the south, it causes a northerly current along the shore, which is especially observable near the entrance of Bombay harbour; but in the open sea, during the same months, the current generally sets to the eastward. In July, when the rivers of the peninsula are swollen by the rains, causing great floods, the current flows stronger to the south. At the entrance of Bombay harbour, however, a southerly current is seldom observed, the freshes setting directly west, and the flood and ebb tide counteracting each other; but south of Bombay the current flows at the rate of from 10 to 15 miles per day, increasing to 18 or 20 miles towards the south part of the peninsula. This southerly current continues during August and September, and is strongest between Cochin and Cape Comorin, where, in August, September, and the early part of October, it is often from 20 to 30 miles per day. When the river floods are very powerful, the current is usually somewhat distant from the shore; between Calicut and Anjenga, it has been observed in a south-south-east and south-east direction, with a velocity of from one to one and a-half mile per hour. To the westward of the Laccadives, in the open sea, the current flows to the east in July and August, and south in September and October.

Indus Current.—The Indus, the mouth of which is situated at the north-east angle of the space of the ocean comprised between Arabia on the west, India on the east, and Persia on the north, discharges a considerable mass of water into the ocean, especially from July to September. At this period, which is that of flood, it forms a southerly current near its mouth, and which, enlarging as it proceeds, takes at its western and eastern limits, the direction of south-south-west and south-east. This current, of limited extent at its origin, and near the south portion of the delta of the Indus, attains a breadth of 240 miles, after a course of 3000 miles; its velocity diminishing gradually in proportion as it recedes from its source, till at this distance it is lost in the ocean.

Persian Gulf.—The Persian Gulf is situated beyond the limits of the monsoons, but from the position and nature of the neighbouring countries, periodical winds prevail, which blow up and down the gulf at different seasons; these produce corresponding drift-currents, which run into the gulf from May to September, and out of it during the remainder of the year.

Red Sea.—The currents of the Red Sea appear to be entirely governed by the winds; during the prevalence of southerly breezes they run to the north, and with northerly winds to the southward: it is probable, also, that they increase with the strength of either, little or no current being perceptible during the prevalence of light variable airs, previous to the setting in of the south winds. In the vicinity of Jiddah harbour the current runs, in the different seasons, at a rate of from one to one and a-half mile per hour. North of Jiddah, the currents are very variable throughout the year, depending on the direction of the wind, which, when strong, causes them to run at the rate of from 20 to 40 miles a-day. From May to October, in the northern part of this sea, the water is two feet lower than in the other months of the year. This is caused by the influence of north winds, which at this season prevail through the whole extent of the sea, and cause a continued current to set through the strait into the Gulf of Aden. From October to May, when the south winds prevail, in the lower part of the sea, these currents change their direction, and flow back with rapidity; the whole body of water, having no means of escape, then collects towards the northern part of this sea, which becomes greatly elevated.[2]

East Coast of Africa.—From the equator, along the east coast of Africa, to Cape Guardafui, and thence along the Arabian coast to Ras al Had and the coast of Persia, a north-easterly current commences with the south-west monsoon in March and April, and continues till September or October, when the north-east monsoon begins and produces a south-west drift current.

Mauritius and Rodriguez.—The existence of currents flowing from east to west in the vicinity of these islands is noticed by Rennel and Horsburgh, and has been fully confirmed by the late Prussian navigators. The cause of these currents is to be sought for in the trade winds, on the south-west limits of which they occur; and a striking example of their effect was experienced during the Rodriguez hurricane in 1843, when the *Victoria* was wrecked on the reefs to the eastward of Rodriguez. The vessel went ashore on the 7th April, three days after the hurricane had passed over the island, and about a month afterwards part of the wreck was picked up on the south-east coast of Mauritius, 300 miles to the westward; which indicates a current running at the rate of about 10 miles per diem.[3]

Cape Counter-Current.—This current carries the waters repulsed by the bank of Agulhas back into the Indian Ocean in high latitudes. In the vicinity of the Cape of Good Hope its mean velocity is estimated at about 50 miles per day. Its easterly course has been observed, according to Rennell, as far as the meridian of longitude 65° 15′ east; and from the circumstance of its being favoured by the prevailing westerly winds, it is extremely probable that its influence extends to the shores of Australia.

South-west Coast of Australia.—According to Flinders, the current divides, near Cape Leeuwin, into two streams, one of which flows north, and the other east, along the coast of Australia. In May and December, he found, between Cape Leeuwin and King George Sound, a velocity of 27 miles per diem; but it afterwards decreased towards the east to 16 and 13 miles.

Molucca, Timor, and Arafura Seas.—The current prevailing in these seas appears to be the same in both monsoons, except that, during the westerly monsoon, there is a set of nearly two miles an hour to the eastward, between the north-east extremity of the Island of Timor and Port Essington, while during the easterly monsoon this set is scarcely perceptible. The current in these seas, which in some parts—the Ombay passage, for instance—sets constantly to the south-west, at the rate of from two to five miles per hour, is evidently caused by the body of water driven in from the North Pacific by the easterly winds which prevail there.[4]

TEMPERATURE AND OCEANIC WARMTH EQUATOR.

The observed temperatures indicated on the line of the warmth equator on the chart, show that the maximum heat of the waters of the Indian Ocean (87° 40′) occurs in the Arabian Sea, between the Strait of Bab-el-Mandeb and the coast of Hindostan. This result we owe to the recent observations of M. T. Philippi,[5] whose measurements, as M. Mahlmann observes, "afford a new but by no means an unexpected proof of the high temperature of the basin of the Indian Ocean." M. Philippi's observations extend from Suez to Calcutta, and show a remarkably regular increase of temperature in the Red Sea in the direction from north to south.

Having, in this chart, completed the delineation of the oceanic warmth equator round the globe, it may be interesting to trace its course through the principal divisions of the ocean; and, commencing at the eastern side of the Pacific, we find that it forms an irregular curve, proceeding westwards from the Bay of Panama, north of the Galapagos Isles, and gradually approaches the terrestrial equator, till, at about longitude 21° east, in the middle of the ocean, it crosses the line and continues to the south of it till it attains its maximum on the northern shores of Papua, at which point it nearly coincides with the terrestrial equator. It then takes a sudden turn towards the south, and, passing through the Molucca and Java Seas, it enters the Bay of Bengal by the Strait of Malacca; thence it continues nearly due west till it reaches the eastern coast of Africa, near the Strait of Bab-el-Mandeb. On the western coast of Africa, it leaves the Gulf of Guinea, north of the terrestrial equator, and maintains a north-westerly course along the shores of South America, and through the Caribbean Sea, attaining the maximum temperature in the Gulf of Mexico. It thus appears that, for about six-tenths of its extent, the line of greatest oceanic warmth lies in the Northern Hemisphere, at an average distance of about five degrees from the equator of the globe; while its average distance from the line, during the other four-tenths of its progress, in the Southern Hemisphere, is about three degrees; and that it coincides with the equator of the globe only at the points where it crosses, and at the Island of Papua.

The maximum temperature of the three great divisions of the ocean is thus found to be—

Pacific Ocean, . .	Latitude 0° 0′	Longitude 135° E.	88°. 52
Indian Ocean, . .	„ 9 95 N.	„ 59 52′ E.	87. 40
Atlantic Ocean, . .	„ 28 N.	„ 83 W.	88. 52
		Mean, .	88. 15
The mean temperature of the equator of heat of the atmosphere is			82. 4
Showing a difference in favour of the heat of the ocean of			6.° 11

On comparing the line of oceanic with that of atmospheric temperature,[6] we find that the latter follows, in general, a more northerly course, about seven-tenths being in the Northern, and three-tenths in the Southern Hemisphere, and that the position of each, in reference to the terrestrial equator, bears a considerable resemblance to the other, the greatest difference being observable in the vicinity of the islands of the Indian Archipelago, and on the western coast of Africa, where the equator of atmospheric temperature is much farther north, and in the Caribbean Sea, where it is much farther south than the other. These differences may be satisfactorily explained by the position of the land in the places referred to, the continent of Africa having a tendency to raise the equator of atmospheric temperature towards the north in the one case, and that of South America to incline it towards the south in the other.

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[1] East India Directory, vol. i. p. 100.

[2] Sailing Directions, Moresby and Elwon's Chart of Red Sea; Lieut. Wellsted, Geographical Journal, vi. 32. Lieut. Maury suggests, that as the hot season extends from May to October, when evaporation is excessive from the dry and hot winds which blow upon this sea—"the depression in the level of its head waters may be owing quite as much to the effect of evaporation as to that of the wind blowing the waters back."

[3] Nature and Course of Storms, p. 12; Nautical Magazine, 1844, p. 528.

[4] Nautical Magazine, 1843, p. 586.

[5] Observations on temperature made on board the steam-ship *Bentinck*, from 24th April to 17th May 1844.—*Monatsberichte der Gesellschaft für Erdkunde zu Berlin*, 1845, p. 124.

[6] See Meteorological Division, plate 18.

METEOROLOGICAL CONDITIONS OF THE INDIAN OCEAN.

For the reasons stated in the introductory note, we have pointed out on this chart the limits of the winds and storms of which the Indian Ocean is the theatre. We shall now briefly describe the extent of these different regions, referring, for an explanation of the various phenomena, to the notes accompanying the chart of the distribution of the currents of air (Plate 19, p. 61), on which we have also given enlarged diagrams and descriptions of the *Rodriguez Hurricane*, and the *Culloden Storm*.

South-East Trade Wind.—As shown by the coloured lines on the chart, the south-east trade or passage wind extends, in the southern part of the ocean, from about latitude 10° to 28° south, within which limits[1] it blows powerfully, and with great steadiness, from April to October, when it extends to within a few degrees of the equator. After this date, when the sun enters the Southern Hemisphere, this force and regularity gradually decrease, and, as the solar heat increases, it altogether disappears, or leaves the vicinity of the equator for latitude 10° or 12° south, which may be considered as its northern limit during the hot season, at which time its southern limit is extended to 29° or even 30° south. South of the zone of the trade winds, we find the district of the north-west winds, which prevail nearly in the same latitudes in the Atlantic and Pacific Oceans.

Monsoons.—The northern part of the Indian Ocean is the region of the monsoons. They prevail over a tract extending from latitude 7° or 8° south of the equator, to the countries of Asia on the north; and from the Channel of Mozambique and the Red Sea on the west, to the shores of Australia[2] and the China Sea on the east.

The monsoons blow during six months of the year in one direction, and during the other six months in an opposite one, the change occurring about the 15th April and the 15th October. On the north side of the equator, the north-east monsoon prevails, with little variation, from October to April; while from April to October the south-west monsoon prevails in the same region. On the south side of the equator, the north-west monsoon prevails at the same time as the north-east monsoon blows on the north, and the south-west monsoon of the north becomes the south-east monsoon of the south of the line. During the hot season, when the south-east trade wind recedes to the southward, the space between the line and 10° or 12° south, is occupied by the north-west monsoon, which then attains its southernmost limit. (*See* Distribution of Winds and Storms, Plate 19, p. 62).

District of Hurricanes.—The hurricanes of the Indian Ocean are confined, generally, to the region extending from latitude 9° or 10° to 30° or 35° south, and from eastward of Madagascar on the west, to the south side of the Island of Timor on the east.[3] Within these limits we have laid down the axes of some of the most authentic storms, showing with what remarkable uniformity they travel from the north-east, in a direction south-west and south towards the east again.[4]

Tyfoons.—These hurricanes prevail on the coasts of China, and extend thence to the east of the Island of Luzon, and north to the Islands of Japan, seldom extending farther to the south than latitude 14° north,[5] and blowing with the greatest violence in the vicinity of the land.

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[1] All these limits are reduced to the mean valuation of the year—they are subject to considerable alterations at the different seasons.

[2] That part of the coast of Australia from Cape York to Cape Van Diemen, and extending as far to the south as the parallel of 12° south latitude, may be said to be within the limit of the east and west monsoons, as at a short distance from the coast these periodical winds will be found to blow with great regularity. *Near* the land, the easterly monsoon sets in between the 1st and middle of April, and the westerly monsoon in October, and sometimes not until November. At a greater distance from the land they are probably more regular, as the changes of the monsoons are said to take place about the first week of April and October. In 1833, the westerly monsoon set in at Port Essington in the first week of November; there had been no rain before that. *Captain Wickham,—Surveys of the Beagle*, App. p. 538. Recent observations have shown that the westerly monsoon extends to the eastward in the Pacific, as far as the Island of Tahiti.

[3] From the experience of Captain Sullivane at Mangaia and Tahiti, as well as observations of other navigators, there is reason to believe that rotatory gales are prevalent in the Pacific as well as in the Indian Ocean.

[4] See Notes on the Hurricanes, Plate 19, page 62.

[5] Mr Piddington says he has not been able to trace them below latitude 11° north.

PHYSICAL CHART

OF

THE PACIFIC OCEAN,

FOUNDED ON THE

OBSERVATIONS WHICH HAVE BEEN MADE FROM THE TIME OF MAGALHAEN TO THE MIDDLE OF THE NINETEENTH CENTURY.

I. INTRODUCTION.

The Pacific Ocean, Great Sea, or South Sea, is an immense expanse of water, bounded on the one side by Asia, the Philippine Islands, and Australia, and on the other by America, extending from the Arctic to the Antarctic circle, through a space of 133 degrees of latitude. It was unknown to Europeans till the year 1513, when it was discovered by *Vasco Nunez de Balbao*, from the summit of a mountain near the Isthmus of Panama. *Magalhaen*, who sailed from America to the Philippine Islands,[1] bestowed upon it the name of Pacific, in consequence of the calm and delightful weather he experienced while navigating its surface.

It is usual to consider this ocean as divided by the equator into the North and South Pacific; but, for facility of reference, we shall adopt the arrangement which divides it into the three following parts:—(1) The *Northern Pacific*, between Behring Strait and the Tropic of Cancer; (2) *Equatorial Pacific*, from the Tropic of Cancer to that of Capricorn; and (3) the *Southern Pacific*, from the Tropic of Capricorn to the Antarctic circle. The French Captain, *Duperrey*, made the first attempt to collect the existing observations on the currents of the Pacific Ocean. His beautiful work,[2] however, extends only to the parallel of the Sandwich Isles, and does not comprehend the Northern Pacific. Since that time, numerous observations have been made, and published in the nautical periodicals of different countries. *M. Dortel de Tessan* has given, in his account of the voyage of the Venus, a chart of the currents met with by the frigate; many of the conclusions arrived at by early observers have been found untenable, and more careful researches have rectified the courses and movements of the different currents. Among the latter may be noticed the more accurately determined course of the Peruvian coast current of cold water, which, from the discoverer of its thermic qualities, is called Humboldt's Current.[3] As represented on the chart, a drift current strikes on the South American coast, and splits into a southern and a northern portion, the former of which forms the Cape Horn,[4] and the latter the Peruvian current. The voyage of Captain Harmssen, from Guayaquil to Valparaiso, August and September 1827, and the observations then made on the direction and velocity of the ocean currents, and the temperature of the air, first made it evident that this cold current spreads out into the open ocean, round the Gallapagos Isles; for the current which, after leaving the Isla Santa Clara, was northerly, turned to the west, and continued for five days in a direction north 50° west, with a mean velocity of eighteen miles in twenty-four hours. Outside the current, the temperature of the air was 76°, while inside (26th to 31st August) the mean was 68°.72, maximum 69°.98, minimum 63°.86. At Callao it is 14° below the normal temperature; at Payta and Cape Blanco it is 10° or 12° below the sea in its vicinity. So remarkable a depression of the temperature of the air in a tropical region, where the water in the open ocean, free from currents, has a temperature of at least 80°, can only be ascribed to the Peruvian coast current of cold water, which is perceptible west of the meridian of the Gallapagos to about latitude 7° 30′ south. Farther west it gradually loses its cooling powers, although it may be traced to the meridian of San Francisco, 44° from the coast of Peru. In reference to the currents in the vicinity of the Gallapagos Isles, Captain Fitzroy remarks, "In some places they run three, four, or even five miles an hour,[5] generally, but not always, to the north-west. On one side of an island the temperature of the sea is sometimes found to be near eighty, while on the other the water is at less than sixty degrees. These striking differences may be owing to the cool current which comes from the southward, along the coast of Chile and Peru, meeting a far warmer stream from the neighbourhood of Panama."

The recently ascertained stream of warm water which enters the Pacific from the Indian Ocean,[6] has in its physical features many points of resemblance with the Gulf Stream of the Atlantic. Sumatra and Malacca correspond to Florida and Cuba; Borneo to the Bahamas, with the Old Providence Channel to the south, and the Florida Pass to the west. The coasts of China answer to those of the United States; the Philippines to the Bermudas; the Japan Islands to Newfoundland. As with the Gulf Stream, so also here there is a counter-current of cold water between it and the shore. The climates of the Asiatic coast correspond with those of America along the Atlantic, and those of Columbia, Washington, and Vancouver, are duplicates of those of Western Europe and the British Islands; the climate of California (State) resembling that of Spain; the sandy plains and rainless regions of Lower California reminding one of Africa, with its deserts between the same parallels. Moreover, the North Pacific, like the North Atlantic, is enveloped, where these warm waters go, with mists and fogs, and streaked with lightning. The Aleutian Islands are as renowned for fogs and mists as are the Grand Banks of Newfoundland. A surface-current flows north through Behring Strait into the Arctic Sea; but in the Atlantic the current is from, not into the Arctic Sea. It flows south on the surface, north below; Behring Strait being too shallow to admit of mighty under-currents, or to permit the introduction from the polar basin of any large icebergs into the Pacific. Behring Strait, in geographical position, answers to Davis Strait in the Atlantic; and Aliaska, with its Aleutian chain of islands, to Greenland. But instead of there being to the east of Aliaska, as there is to the east of Greenland, an escape into the polar basin for these warm waters, the Pacific shore-line intervenes, and turns them down through a sort of North Sea along the western coast of the continent towards Mexico. These contrasts show the principal points of resemblance and of difference between the currents and aqueous circulation in the two oceans. The ice-bearing currents of the North Atlantic are not repeated as to degree in the North Pacific, for there is no nursery for icebergs like the frozen ocean and its arms. The seas of Okhotsk and Kamtchatka alone, and not the frozen seas of the Arctic, cradle the icebergs of the North Pacific.[7]

"A knowledge of the currents and winds of the Pacific Ocean," says Mr Redfield, "will, I am convinced, serve to remove all mystery and all doubt from the once vexed question of the first peopling of its islands from the Asiatic continent, in spite of the long urged objection of the opposition of the trade winds. A case is still recent where the wreck of a Japanese junk was drifted the entire distance to the Sandwich Islands, with its surviving crew; thus completing nearly half of the great circuit of winds and currents in the North Pacific. But we shall find an additional means of transport near the equator, which is afforded in the north-west monsoon of the Indian and Pacific Oceans, and which, according to my inquiries, is found to extend, at one portion of the year, as far eastward as the Society Islands, or more than half the distance from the Indian Ocean to the coast of South America."

The distances mentioned in the chart and notes are reckoned in nautical or geographical miles, sixty of which are equal to a degree of latitude.

The temperature is uniformly given in degrees and decimal parts of Fahrenheit's scale,[8] and the longitude is reckoned from the meridian of Greenwich.

II. NAVIGATION OF THE PACIFIC.

Professor Meyen has communicated the following information on the routes by which the commerce of the Pacific is conducted.—(See also notes on the Navigation of the Atlantic Ocean.)

1. TRACKS FROM AMERICA, &c. TO ASIA.

Examples Coloured Red *on the Chart.*

There are two lines of communication between South America and the southern part of Asia, the one or the other of which is chosen, according to the object of the voyage, or other circumstances. Ships bound from Chile, Callao, or Guayaquil, direct to China, usually steer in a straight line to the Mendana Isles (the Marquesas of the Spaniards, and the Washington Islands of the Americans). In this part of the voyage they are assisted by the south-east trade winds; they then pass to the south of Gilbert Islands and the east of the Pelew Islands;[9] their direction is afterwards determined by the direction of the monsoons in the China Sea. They either sail through the Strait of S. Bernardino, and avail themselves of the south-west monsoon, or north of the Philippines, through the Bashee Isles, and here cut the north-west monsoon. If the navigator on this last route does not exactly observe the required latitude, and approaches the coast of China even a single degree too far to the south, the voyage may be prolonged several weeks. Ships which, on this great route (one of the longest, though the most pleasant) intend to take in fresh water or provisions, sail to the Sandwich Islands, and avail themselves as soon as possible of the north-east trade wind, which blows much stronger, and with greater regularity than the south-east trade. On this route, ships also avoid the frequent calms which prevail in the vicinity of the island groups in the Southern Hemisphere, and add considerably to the length of the voyage. On the voyage in the north-east trade, which ships can always make in a straight direction, they sail to the north of the Sandwich Islands, far above the meridian of the Mariana Islands. From the Sandwich Islands the voyager prefers a course in 12° to 15° north latitude, where he is more certain to find a strong trade wind than in the higher latitudes, especially above 20°; afterwards, he must steer a more or less northerly course, according to the monsoon, in order to arrive at the latitude of Macao. This route is nearly the same as that formerly followed by the Spanish galleon on the voyage from Acapulco to Manila, to the latitude of the Sandwich Islands, where it usually anchored, and afterwards steered to the Marianas, where it came to anchor at Guam or Guahan, in order to communicate the instructions of Government, and take in fresh provisions. Afterwards the galleon directed its course eastward of Manila to Cape Espiritu Santo, on the Island of Samar, near which it was once taken in a celebrated engagement by Lord Anson.

2. TRACKS FROM ASIA, &c. TO AMERICA.

Examples Coloured Blue *on the Chart.*

On the voyage from India to South America, which is generally made during the south-west monsoon, ships keep to the north of the limits of the north-east trade wind, which is usually met with only in latitude 28° and 29° north. Here they are sure to find the so-called western trade, with which they sail to the coast of California, in order to correct their longitude; but if this be not necessary, they direct their course straight to the place of their destination, cutting the trade wind only at an acute angle. Even those ships which are bound for Peru and Chile, usually take the same route; they then sail southwards till they reach the south-east trade wind; they must cut this towards the west, and seek the south-westerly winds in latitudes 26° to 28°, with which they reach the coast, and then sail to the place of their destination. Ships sailing from China during the north-east monsoon, must take their course in the Southern Hemisphere, where the voyage is very dangerous, on account of the numerous islands and coral banks through which they must sail. On reaching the meridian of New Caledonia and New Zealand, however, they may hope for a speedy termination to their voyage, by the assistance of the constant westerly winds; and probably this track will in future be generally adopted. This route may also be taken from Port Jackson and Van Diemen's Land on the voyage to Europe, round Cape Horn, as was lately done by the brig Arethusa, Captain Boulton, who arrived at Cape St John (north-east point of Staaten-Land) in forty-six days from Van Diemen's Land.

3. STEAM NAVIGATION IN THE PACIFIC.

Mr Wheelwright, in detailing his efforts to establish navigation by steam along the coasts of Peru and Chile, says: "The coal mines in Talca[10] are every day improving in quality, and the quantity is unlimited; in fact, the whole southern country is nothing but a mine of coal. It would be difficult to form an estimate of the value of steam on this coast. On my recent return from Guayaquil to Lima (in the steamer), which occupied five days, I had an opportunity of observing it. One vessel sailed four weeks before us, and was thirty-six days. Another Baltimore clipper also sailed from Guayaquil a few days before us, and was twenty-five days, which I consider the average passage of ships sailing from Guayaquil to Lima. From Arica to Cobija we employ two days. A ship which sailed from the former port we passed on the passage; she finally arrived in twenty-two days. These are every-day and most common occurrences, and such extremes of sailing ships *versus* steam-ships can be found on the Pacific.[11]

III. CURRENTS OF THE PACIFIC OCEAN.

1. PERUVIAN COAST, OR HUMBOLDT'S CURRENT.

The following luminous and interesting description of this current is abridged from a manuscript memoir by the discoverer of its thermic proportions, A. Von Humboldt:—

"As the existence and general direction of the Gulf Stream has been known, by its temperature, to European navigators for a century past, so also in the Pacific Ocean the existence of a great ocean current, from south to north, and north-north-west, has been observed since the time of the earliest intercourse between Chile, Lima, and Guayaquil; but the low temperature of this current, and its important influence on the coldness of the Peruvian coast, which was erroneously ascribed to the vicinity of the snow-capped Cordilleras, were, on my arrival on the shores of the Pacific, totally unknown.

"In the year 1775, Franklin expressed the hope that philosophers would yet discover cold currents in the ocean, conveying water from higher to lower latitudes, as he had shown that the Mexican Gulf water, flowing from lower to higher latitudes, communicates to them a part of the tropical heat of the Azores, and even of the Cantabrian Sea. Almost thirty years passed away before this hope of the great man was fulfilled, since, between La Condamine's expedition and my own, that part of the world was explored only with a view to astronomical and astronomico-geographical researches by Ruiz and Pavon, as well as by the companions of Alessandro Malaspina. At the distance of eighteen months' travel from the shores of the Atlantic Ocean, I had a great desire to see the Pacific, and to continue in the Southern Hemisphere those observations on the temperature of the sea which had so agreeably occupied me in the Northern. The first concern of a traveller on arriving at the sea coast, after a long absence in a mountainous country, is to observe the height of the barometer, and the temperature of the water. I was occupied with the latter in a district between Truxillo and Guaman, near Callao de Lima, and on the voyage from Callao to Guayaquil and Acapulco, on a tract of the Pacific Ocean of more than 400 miles in extent, when, to my great surprise, I found that the temperature of the surface of the sea under latitudes where, outside of the current, the temperature ranges from 78°.8 to 83°.3, was at Truxillo, at the end of September, 60°.8; and at Callao, in the beginning of November, 59°.9. The temperature of the air was in the first period, 64°.04, in the second, 72°.86 and thus (which it is of importance to remark) 12°.6 warmer than the ocean current.

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[1] The probable track of Magalhaen's squadron is given on the chart according to Krusenstern.

[2] Carte du mouvement des eaux à la surface de la mer dans le Grand Océan Austral; Par le Capitaine Duperrey. Paris: 1831.

[3] See Meyen's Reise um die Erde, ii. bd., p. 52; and Berghaus' allgemeine Länder und Völkerkunde, i. bd., p. 584; Geographischer Almanach auf das Jahr 1837, p. 309.

[4] The existence of the Cape Horn current, which carries the drift-wood of Tierra del Fuego eastward of the Falkland Islands, was at one time called in question; but it has been completely established by the careful observations of Captain Foster.—Voyage of the Chanticleer, vol. ii., p. 268.

[5] Journal of the Royal Geographical Society, vol. vi., p. 333.

[6] See Plate XIII., p. 49.

[7] Maury's Physical Geography of the Sea; and Findlay, Journal Royal Geographical Society, vol. xxiii., p. 230.

[8] The original observations on temperature having been generally reckoned in degrees and parts of the centigrade scale, have, when reduced to that of Fahrenheit, less of the character of round numbers than in many cases they were intended to express.

[9] See the southern, or long route from South America to China, on the chart.

[10] Talca is situated in latitude 35° 30′ south, longitude 70° 51′ west.

[11] Silliman's American Journal, vol. xliii., p. 297. See notes on Indian Ocean, p. 58.

"Thus the air could not possibly have cooled the water; and without having at that time an intimate knowledge of the climate of Peru, or of the period when the 'garua'[1] prevails, I stated at Truxillo, on my first arrival on the coast, the opinion which has since been confirmed by many voyagers, namely, that the Peruvian stream is a polar current, which, flowing from higher to lower latitudes, follows the sinuosities of the coasts in a north-north-west direction, and that the perceptible amount of cold which is felt in the tropics, a few feet above the surface of the ocean in the so-called Desert of Lower Peru, is owing to the low temperature of the sea, and the interrupted action of the sun's rays during the period of the garua. As often as I could ascertain the temperature of the water at Callao in October and November, it was found to be between 59°.9 and 60°.8—at night scarcely 0°.7 colder than by day; only once it sank in a few hours to 59° and 58°.55, when (which is characteristic of this tranquil part of the Pacific, and considered by many of the inhabitants of the shores as the consequence of a submarine volcanic movement), with the clearest sky in a perfect calm, an immensely high and hollow breaker suddenly began to dash upon the granite coast.

"Apparently this last reduction of the temperature to 58°.55 arose from the same cause by which, according to my ideas, the water over a sand-bank is cooled. By the deep, perhaps volcanic, movements of the ocean, the lower stratum of water is mixed with the upper, arriving, as it were, on the plateau of a submarine island, as by pressure they ascend upon a sand-bank. From the beginning of November till the end of December, I observed the temperature gradually increasing; it rose to 69°.8, and the regularity of this increase was afterwards fully made known by the researches of my friend Duperrey in 1825. On the 25th December 1802, I sailed from Callao to Guayaquil, in search of a ship which might carry me to the western coast of Mexico. On this whole voyage I had an opportunity of observing the extension of the cold current towards the north-west, and the remarkable influence which it exercises on this, the most westerly point of the South American continent, between Punta Pariña and Cabo Blanco. The configuration of the Peruvian coast affords two points; first under the 18th and then under the 5th degree of latitude, in the most concave and the most convex part of its curve, points which correspond with the convexity of the Cape de Verde, and the concavity of the Gulf of Biafra, on the western coast of Africa. These turning points of the western coasts, the one of which lies in the Southern, and the other in the Northern Hemisphere, modify, by the position of the land in reference to the ocean and the prevailing winds, at once the ocean currents, the climate, and the character of vegetation. In the New World this influence of the western direction of the coast, and form of the continent, is so much the more powerful since here (and here alone) it runs almost parallel with a high mountain chain (that of the Andes) in its vicinity. The following notes contain the facts and opinions which first presented themselves to me as I recorded them at the time, on the ocean. The current favours every voyage on these coasts, from south to north, to such an extent that one may easily sail in four or five days from Callao to Guayaquil, and in eight or nine days from Valparaiso to Callao (a distance of more than sixteen hundred miles), when on the return up the current, several weeks, and in some cases even months, are required. On my voyage, the increase of temperature of the cold current, as I drew near the equator, to 4° 30′ south latitude, was not considerable, scarcely amounting to 2°.16. As long as we were in the current the temperature of the sea was 69°.8 to 72°.14. The fear that, notwithstanding the great depth of the sea on the Peruvian coast, the vicinity of the coast itself might have modified the climate, was soon dispelled, when in the open sea, one hundred or one hundred and twenty miles from the continent, the temperature of the water was found to be still 69°.8, as between Callao and the Island of San Lorenzo. The current turns suddenly towards the north-west, at Cabo Blanco, and we passed, in the course of a few hours, from water the temperature of which amounted to 68°.72 and 69°.08 into that of 80°.6—a difference of 12 degrees.

"Is the origin of the cold current to be sought for near the outlet of Magalhaen Strait, at Cape Pilares, where in November the temperature of the sea scarcely amounts to 41° or 42°? An intelligent Spanish seaman, Don Josef de Moraleda, who commanded the ship in which I made the voyage from Callao to Guayaquil, assured me that, in the Archipelago of the Islands of Chonos and Huaytecas, the coasts of which he had explored, he had found the movement of the water which flows along the coast towards the north to be very slow. On the surface, it only moved at the rate of from three to five tenths of a mile per hour, as in a drift current; but careful observations with the lead had shown, that at a depth of from twelve to fifteen fathoms, the current in the same direction is much stronger. The agitated parts of the water, flowing between warmer layers, long maintain the low temperature of higher latitudes, and remain at a depth corresponding to their specific gravity.

"From Valparaiso and Coquimbo, but especially from Arica, north to Lima, the current at the strongest runs from twelve to fourteen, and sometimes even eighteen miles in twenty-four hours.

"It is observed in this, as in all other ocean currents which strike against a suddenly trending shore, that the impediment hastens its course, and, consequently, the maximum velocity is found along the coast. This force of the current is the cause why ships which, at the time of the garua, sail from Quilca to Callao de Lima are unable, for several days, to obtain any observations for latitude; and, prevented by the fog from ascertaining their position on the coast, they are often, to their great disappointment, carried past the harbour of Callao to Huaura and Guarmey, while, according to log-reckoning the voyager believes himself to be still to the south of Callao. The mist and fog are most dense between Pisco and Lima.

"The voyage against the stream from north to south is so toilsome, that in sailing from Paita or Callao to Valparaiso or San Carlos de Chiloe, ships, in order to avoid the current, take a course more than eight degrees to the westward of Juan Fernandez; and a Spanish frigate, the Santa Rosalia, on the voyage from Paita to Valparaiso, was carried so far to the west, apparently by the Equatorial Current, as to touch Easter Island (Isla de Pascua or San Carlos of the Spaniards), longitude 109° 17′ west. When the Peruvian Coast Current has reached its maximum, between Arica, Quilca, and Lima, it flows to the north-west. Between Lima and Cabo Blanco, where it suddenly leaves the coast,* and mixes with the general *Rotation*, or *Equatorial Current*, its mean velocity, according to my observations, was from seven to eight miles in twenty-four hours. The local condition of the coasts at this turning point, and their easterly trending beyond Punta Pariña and Cabo Blanco, together with the absence of an ocean current, with a temperature so low as 69°.08, are undoubtedly the causes of the greater warmth of the coasts of Guayaquil, and the totally altered condition of the atmosphere north of the Cerro de Amotape."

Twenty years after his return to Europe, Baron Humboldt had the satisfaction to see the truth of the observations first made by him in the eastern part of the Pacific, which led to the discovery of this cold current, and its influence on the climate of Peru, fully established by three eminently talented travellers—the French Captain Duperrey, the Danish Lieutenant Dirckinck Von Holmfeldt, and the Prussian naturalist Dr Meyen, in their observations made during the years 1823, 1825, and 1831, in the most opposite seasons.

On comparing the mean value of the observations on temperature made at Callao with those under the same parallels in all other parts of the globe, Duperrey finds the following result, which places the phenomenon of the cold current of Peru in the clearest light :—

	Air.	Ocean.
The mean temperature under latitude 12° south, ...	79°.34	79°.70
Do. at Callao de Lima, latitude 12° 3′ south, 26th Feb. to 4th March,	68 .36	65 .66
Difference, ...	10°.98	14°.04

If, instead of the mean value of all the observations, we take those only which refer to the Southern Pacific, bounded on the east by the Peruvian coast, we find a still more remarkable difference. In this case the difference in the temperature of the air is 10°.28, and for that of the ocean 14°.40, in the harbour of Callao.

The following is the difference of the highest and lowest state of the thermometer for all the observations of Duperrey, in the Atlantic, Pacific, and Indian Oceans, as compared with that of Callao :—

	Maxima.		Minima.
Temperature of the air, ...	8°.80	.	13°.32
Temperature of the sea, ...	12 .42	.	19 .26

At Paita (latitude 5° 6′), Duperrey found the temperature of the current, between the 11th and 22d March 1823, always between 68°.90 and 77°, mean 72°.95, whilst in the ocean, outside of the cold current, the mean was 80°.60.

Baron Dirckinck, at the request of A. Von Humboldt, made a long series of observations on the Peruvian Cold Current in the years 1824 and 1825, the results of which coincide in a striking manner with those already stated. Humboldt observes, that in this table of the temperature of the ocean between Callao de Lima and the equator,[2] "the change from the temperature of the cold current to that of the adjoining sea, north of the parallel of Cabo Blanco, is very remarkable. Between the 4th and 5th April it rose from 71° and 72°, to 80° and 83°." "I found it [he remarks] about the same region change from 70° to 80° Fahr."[3]

"Duperrey has given entirely new views on the origin of the cold current of the coast of Peru. By comparison of the observations of numerous voyagers furnished with chronometers, this experienced officer has shown that between the meridian of the South Cape of New Zealand and Pitcairn Island, a mass of water moves in an extent of more than sixty degrees of longitude, as a *Drift Current*, driven by melting ice and the prevailing south-south-west winds from the south pole—first towards the north-north-east, and then north-east, and lastly towards the east-north-east, when, meeting the coast of Chile, between Conception and Valparaiso, it divides (in a manner similar to that of the Equatorial Current on the Brazilian Coast, near Cape St Augustine), one part flowing south along the coast by the Island of Chiloe, the Archipelago of Chonos, and Cape Pilares, to Cape Horn, and the other northwards by Arica, Callao, and Paita, to Cabo Blanco.

"This view, embracing an immense extent of ocean surface, places at a distance of thirteen hundred geographical miles the origin of the Peruvian Cold Current, and increases a phenomenon of the Southern Hemisphere, which has so long occupied my attention, to the importance of that of the Gulf Stream of Florida, as shown by Rennel's researches, if followed upwards from the Agulhas Bank, at the Cape of Good Hope."[4]

2. EQUATORIAL CURRENT.

According to the careful observations of Duperrey, the current which flows from the Antarctic Ocean towards the coast of America, turns suddenly, at the distance of twenty-two degrees of longitude, from the continent, under latitude 20° south towards the west, in order to form the great Equatorial Current of the Pacific Ocean, which, in general, following the impulse of the trade winds, runs in a westerly direction. He calculates that the southern limit of this current coincides with the parallel of 26° south, while its northern border may be reckoned at about 24° north. So that the oceanic water moves in a westerly direction over a space of 50 degrees, or nearly the third part of the distance from pole to pole.

3. MEXICAN COAST CURRENT.

Passing over to the Northern Hemisphere, we find first the Mexican Coast Current, an alternating current which is occasioned by the monsoons of the coast. A. Von Humboldt first gave a description of this current; and Basil Hall and Beechey afterwards furnished contributions towards its elucidation.

4. FLEURIEU'S WHIRLPOOL.

I have named the current in the eastern division of the North Pacific Ocean Fleurieu's Whirlpool, after the learned hydrographer of that name, who has described Marchand's voyage, in a work which ranks in the highest class of modern nautical literature. The whirlpool is laid down from the observations of Marchand; and since it is not contradicted by the animadversions of Lütke, who sailed directly through its course, I have considered myself justified in laying it down provisionally.

5. CAROLINIAN MONSOON CURRENT.

The monsoons of the Indian and China Seas exercise their sway to the meridian of the Mariana Islands, and the middle of the Carolines. Here they engage in conflict with the trade winds, and occasion an alternating motion of the water, which I have called the *Carolinian Monsoon Current*. It flows often with great velocity, especially in the western districts. However, it is remarkable that westwards from the Marianas, the Equatorial Current seems to be prolonged constantly, and not to be under the influence of the monsoon; but appears to be again active in the JAPANESE CURRENT, which Mr Findlay traces across the entire breadth of the North Pacific (Geographical Journal, vol. xxiii., p. 229).

6. PENJINSK OR PENSCHINSK CURRENT.

In that part of the North Pacific Ocean which we call the Sea of Okhotsk, known in Kamtchatka and Siberia only by the name of the Sea of Penjinsk or Penschinsk,[5] constant south-east and easterly winds blow in the months of June, July, and August, and easterly winds prevail throughout the whole year. In consequence of this, there are easterly currents of the ocean which flow in the direction of the coast. These are represented according to the observations of Captain Minitzkoi, who, for eight years, was commander in Okhotsk.[6] Adolf Erman has favoured me with an abstract of his ship's journal on the voyage from Okhotsk to Tigil, which gave him an opportunity of verifying the animadversions of Minitzkoi. The track of Erman's voyage through the Pacific Ocean is that of Captain Hagemeister, from Sitka, by San Francisco and Tahiti, to Cape Horn, which is traced on the chart.

7. NORTH EQUATORIAL COUNTER CURRENT.

Between latitude 5° and 10° north, and between the meridians of 115° and 150° west, occurs the remarkable stream which I have called the North Equatorial Counter Current; and in the parallel of the Sandwich Islands, the entanglement of the easterly currents—two phenomena which the numerous observations of the Prussian navigators have established beyond a doubt.

Besides Freycinet, who was acquainted with the latter phenomenon, and Duperrey, who observed it in the Archipelago of the Carolines, Beechey also found it to the west of the Sandwich Isles; and Lütke has collected numerous facts proving the existence of this counter current, which is met with in the middle of the most powerful trade winds.

Meyen has attempted to explain it,[7] and I have given an opinion on the probable cause of this extraordinary phenomenon,[8] with deference, however, since a seaman of such experience as Admiral Lütke says that the observations are not yet numerous enough to warrant a general opinion in regard to it.[9] On this subject Mr Redfield makes the following remarks :—

"The numerous archipelagoes of islands, and the extensive groups of coral reefs in the Pacific, serve to intercept the regular westerly progress of its warm intertropical current, and to determine more than one circuit of compensation and revolution in each hemisphere. This class of obstructions partly supplies the place of a continent, in defining separate basins of revolution for the currents of this vast ocean; and this is particularly the case in the South Pacific, where these obstructions are scattered over wide areas. Hence strong currents setting to the eastward have been found in various parts of the Pacific, below the latitude of 30°, moving in direct opposition to the influence of the strongest portion of the trade winds." (See Findlay, Journal Royal Geographical Society, vol. xxiii. p. 234.

8. MENTOR'S COUNTER DRIFT.

In the Southern Hemisphere, about the Tropic of Capricorn, the observations which were made on board the Prussian Seehandlungs vessel Mentor, in the year 1823, indicate the motion of a current which is directly opposed to the great Equatorial Current.[10]

I have represented this remarkable phenomenon under the name of *Mentor's Counter Drift*, in order to call the attention of voyagers to its existence, and to recommend further observations upon it, but without being prepared to say, from these observations taken by themselves, that this drift stream is always easterly; although not only La Perouse and Kotzebue's animadversions, but those of Duperrey, and, in some measure also, the observations of Lütke on the 23d and 24th April 1827 appear to show that it is non-periodical.

9. ROSSEL'S DRIFT.

From the Friendly Isles, westward to New Caledonia and the New Hebrides, the Equatorial Current, which hitherto, with very little exception, has run uniformly westerly, takes a decidedly north-west and west-north-west direction, flowing into the Corallian Sea and Torres Strait.[11] This phenomenon is undeniably connected with the trade wind, in so far that the constant winds blow more from the south than from the east in these regions. It must be remarked, however, that in this isle-bedecked sea it is often interrupted. I have called this north-west stream Rossel's Drift, in honour of the learned admiral of that name, who, in the narrative of the Expedition of D'Entrecasteaux, first made its existence known. Darville, in the *Astrolabe*, found it at the rate of 29 miles in 24 hours.

NEW SOUTH WALES ALTERNATING CURRENT.—It has long been believed, and is still asserted,[12] that there is a constant current along the coast of New South Wales, depending on the great Equatorial Stream, and having a constantly southern direction. The observations of Flinders, King, and Oxley, favour this view, but Lieutenant C. Jeffreys is of opinion, that "from the parallel of 28° south to the south of Van Diemen's Land, the current flows during the summer months (*i. e.*, from August or September to April or May) as follows : From the land, to a distance of seven leagues to the south-west, one and a quarter mile per hour; in the space between seven-and-twenty leagues distant from the land towards the north-east, three quarters of a mile per hour; and in the winter in an opposite direction."[13] This opinion, however, has not been corroborated by later observers, and the settlement of this question, so important to the navigation of these seas, must wait for farther investigations.

IV. TEMPERATURE OF THE PACIFIC, AND POSITION OF THE OCEANIC WARMTH EQUATOR.

Mention has already been made of the line of greatest ocean warmth, and its position in the eastern part of the Pacific. At first I had made this line cut the terrestrial equator under 178° 40′ of longitude, and carried it thence through the middle of New Guinea and the southern border of the Celebes; but a minute examination of Duperrey's observations has shown that the position of the oceanic warmth equator should be as it is represented on the chart. This line is, of course, only theoretical; it expresses the axis of a zone, in which the water of the ocean possesses a more or less uniformly high temperature. I find the position and temperature of this axis in the western part of the Pacific, and the contiguous Molucca Sea, according to Duperrey's observations, as follows :—

Indication of the Position.	Latitude.	Longitude.	Temperature.
1. South of Gilbert's Archipelago, .	6° 30′ S.	174° 50′ E.	84°.74
2. North side of New Guinea, . .	0 19	137 00	84 .76
3. Near the Island Waigiu, . .	0 02	130 42	84 .74
4. In the Molucca Sea near Ombay, .	8 06	124 28	84 .56

This uniformity of temperature, in a space of more than 50 degrees of longitude—*i.e.*, in the seventh part of the circumference of the earth—is no less surprising than its agreement with the observations of Humboldt on the coast of Esmeraldas and Choco, in the Northern Hemisphere. We may, then, without hesitation, state the normal temperature of the oceanic warmth equator in the Pacific Ocean to be 84°.74. Fahr.,[14] or higher than that of the Atlantic; whence it is evident that the cause of the temperature under the meridian of 115° west longitude, being nearly 5 degrees lower than this, is to be ascribed alone to the cold water of the Peruvian Current. And thus we see that, as the Gulf Stream in the temperate zone pours warm water into the North Atlantic Ocean, so the *Peruvian Coast* or *Humboldt's Current*, nearly three thousand geographical miles distant from the shores of America, empties cold water into the Pacific Ocean within the torrid zone. It has been remarked above that Beechey had found the belt of warm water in the eastern part of the Pacific Ocean, and indeed in the Northern Hemisphere, nearly 14½ degrees of the meridian broad. The maximum warmth observed by him, on the northern border of the belt, was 88°. In the western part, between longitude 172° and 177° east, Duperrey found the zone 21 degrees broad, and extending from latitude 18° south to 3° north. Within this space, the temperature of the ocean water was 84°.2 and upwards;[15] it only fell four times under this; once it rose to 86° (in latitude 4° south); and at another time it amounted to 86°.36 by which the maximum of these numerous observations was attained.[16] An equally high maximum was observed at Waigiu (at 4 P.M.), a maximum of 86°.90 (also at 4 P.M.) in latitude 0° 2′ north, longitude 140° 47′ east. In the Molucca Sea the maximum was 87°.8, in latitude 7° 45′ south, longitude 125° 9′ east; and the absolute maximum in the Haven of Dorerei, New Guinea, latitude 0° 52′ south, longitude 134° 7′ east, was observed to amount to 88°.52. The figures indicating the temperature of the ocean, placed on the parallels of the chart, are taken from my sketch of hydrography.[17] There are, besides, a row of figures showing the temperature on the line between Paita in South America (latitude 5° south) and the New Hebrides (latitude 15° south), which we owe to Duperrey; these are valuable as indicating the state of ocean warmth within the torrid zone, in the direction from east to west.

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[1] During the garua the atmosphere loses its transparency, and the sun is obscured for months together. "The vapours of the garua of Lima are so thick that the sun seen through them with the naked eye assumes the appearance of the moon's disc. They commence in the morning, and extend over the plains in the form of refreshing fogs, which disappear soon after mid-day, and are followed by heavy dews which are precipitated during the night."—*Edinburgh New Philosophical Journal*, 1845, p. 79.

[2] See tables of temperature from Callao to the Equator, &c., Berghaus' Länder und Völkerkunde, i., 587.

[3] A. Von Humboldt's MS.

[4] Ibid.

[5] The "sch" in the word Penschinsk is pronounced soft like the French "*j*."

[6] Krusenstern, Rec. de Memoires Hydrographiques, t. i., p. 24.

[7] Meyen's Reise um die Erde, ii., p. 87.

[8] Geographischer Almanach, 1837, pp. 332, 333.

[9] Voyage autour du monde. Partie nautique, St Petersburg, 1836, in 4to, p. 188.

[10] Geographischer Almanach auf das Jahr 1837, p. 315.

[11] Flinders' Voyage to Terra Australis, ii., 296.

[12] As by my friend Professor Meinicke, in his excellent work, "Das Festland von Australien," i., p. 190.

[13] General Chart of Terra Australis, from the surveys of Captains Flinders and King, R.N., with additions from Lieutenants Jeffreys and Roe, &c. London: 1829. Compare Krusenstern, Rec. de Memoires, i., p. 33.

[14] If we take the mean of Beechey's observations into account, the general mean will be raised by 0°.06.

[15] Twice, however, it fell to 84°.02 in latitude 2° 11′ south, and 9° 44′ north.

[16] This was in latitude 15° 40′ south; then the temperature fell on the following day to the mean of 84°.2, and even to 82°.4.

[17] Berghaus' Länder und Völkerkunde, i. bd., p. 591.

* It has since been ascertained that at certain seasons the current sets to the northward of Cape Blanco, along the coast to the Bay of Panama.

PLATE 15

NOTES

EXPLANATORY OF

THE TIDAL CHARTS OF THE WORLD

AND OF

THE BRITISH SEAS.

BY

J. SCOTT RUSSELL, Esq., M.A., F.R.S., Ed., &c.

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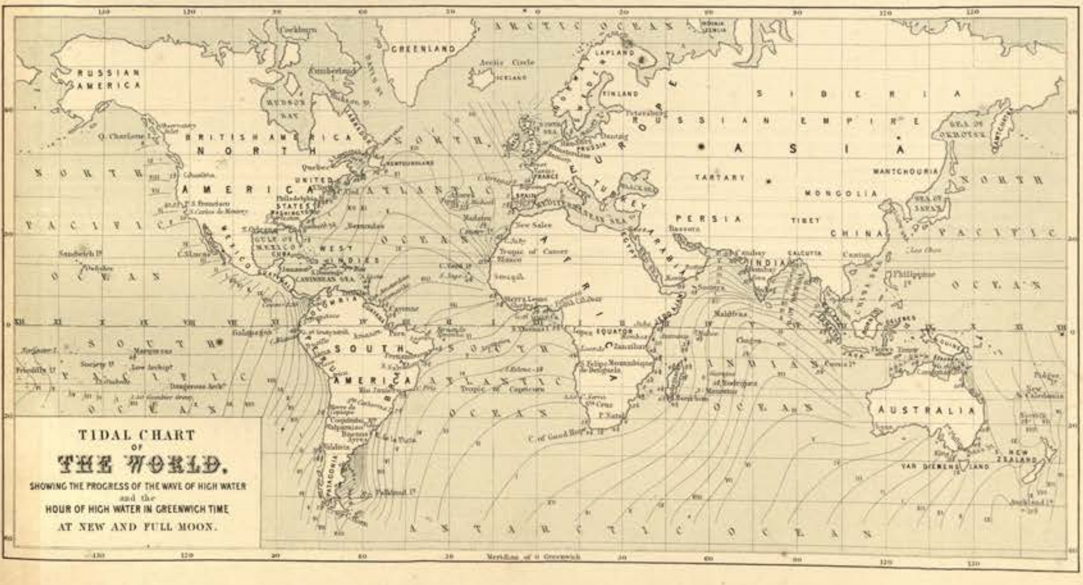
INTRODUCTION.

If the earth presented a uniform globe, with a belt of sea of very great and uniform depth encircling it round the equator, we should have a rise of tide, or high-water, following the sun every day from east to west after mid-day, and another succeeding it after mid-night, when the sun had passed the meridian of our antipodes. This phenomenon Sir Isaac Newton deduced from the laws of the gravitation to each other of the mass of the sun, the mass of the earth, and the mass of the water. In like manner, each transit of the moon over the meridian would bring after it also a tide or high-water; and owing to the smaller distance of the moon, its effect would be greater in raising the water than the effect of the sun, in a proportion nearly six-fold. In this state of matters we might expect four tides a-day. These, however, would so modify each other as to produce only two great tides compounded of the four. When the transit of the sun and moon took place together, their joint effect would raise a tide measured by the sum of the effects; that is, the lunar tide would be increased one-sixth by the solar tide. But, on the other hand, when the transit of the moon was about six hours later or earlier than the sun's, the low-water of the one would diminish the effect of the high-water of the other, and so the lunar tide would be diminished by one-sixth. Thus the mean tidal elevation of high-water would vary in nearly the proportion of 5 to 7. At new and full moon the tides would range higher (forming spring-tides), and at the first and third quarters the tides (forming neap-tides) would range lower. Where there were twenty-one feet of rise of high-water above low-water at springs, there would only be fifteen feet at neaps. Had the earth been formed as we have supposed, with a great equatorial canal, or central belt of ocean, the phenomena might have taken place as we have stated, with great regularity, and we should not have required to form a tidal map or chart, for the crest of high-water would have been nearly (not exactly) a meridional line following the sun and moon at certain very simple intervals. This simple case is, however, very different from the fact, the heights of successive tides and their intervals vary much in the way we have described, but the direction of motion and the epoch or date of high-water are exceedingly various; so different, indeed, that no adequate notion of tidal phenomena can be formed, without some such tidal charts as accompany this paper.

Looking at the Chart of the World, we observe that there is no great equatorial sea extending east and west round the globe, in such a belt as has been imagined. On the contrary, the great continents cross the equator nearly at right angles; the Atlantic running nearly north and south, between Europe, Africa, and the Americas. The chief region of water appears in reality to surround the south pole, and if we recollect how peculiar the nature of the Pacific is, how much it is intercepted with coral reefs and islands, and insular continents, we shall readily perceive how far it is removed from the condition of an equatorial canal of uniform, unimpeded, great depth; presenting, on the contrary, a coral barrier nearly impervious to tidal action.

The source of the tides is therefore to be sought in the great reservoir of ocean round the southern pole. This polar reservoir is agitated on opposite sides by the moon in its alternate lower and upper transits, and by the sun in a less degree. Here the great central agitation seems to commence, and hence on all sides it seems to flow northwards. From the south pole this great agitation flows into the Indian Ocean, and proceeding northward, the great tide-wave strikes with violence on the shores of Hindostan, and finally breaks in the mouths of the Ganges, where it expends its force on the shores in the form of the well-known and terrific bore of the Hoogly. The Atlantic, in like manner, receives from the southern reservoir its great wave of tide, which passes northward with impetuosity, and expends its forces on the shores of Britain and North America, where again it becomes the enormous stream-tide of the Bristol Channel, and the destroying surge of the Bay of Fundi, so well known to all mariners. From the south, in like manner, the Pacific should receive its great tide, were it not barricaded out by innumerable submarine steppes, and its thousand coral reefs, and its myriads of happy islands, to whose calm seas no propagation of this great horizontally-acting wave can gain access. It is by depth and uninterrupted bottom only that a great wave like the tide can force entrance,—it is only the small waves raised by a local tempest, that travel over the surface—an action like the tide, extending uniformly to all depths of ocean, cannot be propagated on a superficial coating alone. The tides are built out of the Pacific by submarine works, and enter it alone and with difficulty by the eastern side of America, where, diffused and rapidly diminishing, the tide extends a certain way through the more open parts of the sea, continually diminishing in intensity. In the North Pacific we have neither the bores of a Hoogly, nor the terrific tides of a Bay of Fundi. It is thus that we shall best understand the tides of these northern seas, in tracing them back to their genesis by the joint actions of the sun and moon on the waters of the Southern Polar Ocean. There we must conceive that the elevation and horizontal motion are first communicated to a vast mass of deep water, which, imparting this impulse to all the surrounding mass, sets in motion the waters of all the southern mouths of our seas, and propagates to our shores, long after their original force has been impaired, the effects of the derangement of the equilibrium of that central reservoir from which alone our tides are derived. It is this course of transmission of tides from south to north by means of a great tidal wave, which is exhibited in the annexed Chart of the World. The chart exhibited now enables us to follow the history of a tide.



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I.—TIDAL CHART OF THE WORLD.

The first idea of a tidal map appears to have been given by Dr. Thomas Young, who exhibits in one of the plates of his Natural Philosophy, by shaded lines, the presence and progress of a great northern tidal wave on the east coast of Britain. The present extended tide map is taken from the map of Sir John W. Lubbock, constructed for his paper on Tides in the *Philosophical Transactions* of 1831; which paper and map have formed the foundation of much that has been done, during the last fifteen years, for the advancement of our knowledge of the phenomena of tides, and for their practical prediction. In that paper he also designates by the term cotidal line, an imaginary line connecting places to which high-water is brought at the same instant by the same tide; and he exhibits on the coast the hours of observed high-water at full and change. On this map cotidal lines were afterwards drawn by the Rev. W. Whewell, now Master of Trinity; and though these are imaginary, and likely to change with our extended knowledge of the form of the bottom of the sea, and the registers of the oscillations of its surface, they may be taken as tolerable representatives of the probable phenomena of the tide. In general a cotidal line will represent the place of the summit of a wave of high-water as it passes successive points along the coast.

It may now be useful to follow the phenomena of the succession of the tides, as indicated by the Chart of the World. Commencing with new or full moon, let us take the spring-tide, or largest tide formed by the coincidence of the actions of sun and moon. Let us conceive that this joint action has taken effect on the waters of the Antarctic Ocean—that the luminaries, in conjunction or opposition, have passed over the mass of waters lying east from Van Diemen's Land, New Zealand, and the South Pole, and have communicated to them motion in the direction of the resultant forces; we shall manifestly have a mass elevated and moving to the north and west, following the luminaries. The motion thus communicated to this mass of water has raised a large mass, or moving ridge of water, which cannot expend its forces acquired, but by pushing before it other masses of water, and raising them, too, in a wave to which all its force is finally imparted. In this way, the wave originally generated travels northward and westward, long after the bodies generating it have ceased to act on the first mass of water. The wave generated during the transit of the sun and moon on Monday morning, and producing high-water on the coast of Van Diemen's Land at twelve, has by noon nearly reached the point of the Peninsula of Hindostan, and at one afternoon is at the Cape of Good Hope. Here it enters the Atlantic, and, travelling northwards, brings high-water at the same hours to the western coasts of Africa and the eastern shores of America.

All these seas, save the Antarctic, have the tides delivered into their mouths at the southern aperture. The Antarctic is the cradle of the tides. It is here that the sun and moon have presided over their birth, and it is here also that they are, so to speak, abandoned to the guidance of their own congenital tendencies. The luminaries continue to travel round the earth (apparently) from east to west. The tides no longer follow them. The Atlantic, for example, opens up to them a long deep canal, running from north to south; and, after the great tidal elevation has entered the mouth of this Atlantic canal, it moves continuously northwards; for the second twelve hours of its life it travels north from the Cape of Good Hope and Cape Horn, and at the end of the first twenty-four hours of its existence, has brought high-water to Cape Blanco on the west of Africa, and Newfoundland on the American continent. Turning now round to the eastwards, and at right angles to its original direction, this great tidal wave brings high-water, during the morning of the second day, to the western coasts of Ireland and England. Passing round the northern Cape of Scotland, it reaches Aberdeen at noon, bringing high-water also to the opposite coasts of Norway and Denmark. It has now been travelling precisely in the opposite direction to that of its genesis, and in the opposite direction, also, to the relative motion of the sun and moon. But its erratic course is not yet complete. It is now travelling from the northern mouth of the German Ocean southwards. At midnight of the second day it is at the mouth of the Thames, and it is not till the morning of the third day that this wave fills the channels of the Thames, and wafts the merchandise of the world to the quays of the port of London. In the course of this rapid journey, the reader will have noticed how the lines in some parts are crowded together closely on each other, while in others they are wide asunder. This indicates that the tide-wave is travelling with various velocity. Across the Southern Ocean it seems to travel nearly 1000 miles an hour, and through the Atlantic scarcely less; but near some of the shores, as on the coast of India, as on the east of Cape Horn, as on the east of the American Isthmus, as round the shores of Great Britain, it travels very slowly: so that it takes more time to go from Aberdeen to London, than over the arc of 120°, which reaches between 60° of southern lat. and 60° on the north of the equator. These differences fall to be accounted for: and the high velocities are invariably found to exist where the water is deep, while the low velocities occur in shallow water. We must, therefore, look to the conformation of the shores and bottom of the sea as an important element in the phenomema of the tides.

II.—TIDAL CHART OF THE BRITISH SEAS.

In the Large Map of the British Seas it will be observed, that we have indicated the depth of the sea, and the conformation of the bottom, in a manner at once sensible to the eye and precise. The darker shades of the sea indicate greater depths, and the marginal line, bounding any given shade, has marked upon it the exact number of fathoms found all along that line. The eye can thus trace the exact form of the bottom of the sea, as if seen through the waters, on the surface of which the crest of the tide-wave is also visible. It will be useful to study these two phenomena in immediate relation to one another on this map; and also to look at the large map, in connection with the smaller, on the preceding page. The reader will thus understand how the Atlantic wave is first brought to the British Seas, and how next it is distributed through the English and Irish Channels, and across the German Ocean. The explanation of these complex phenomena, as exhibited in the Map of the British Seas, is only to be thoroughly given by considering the tide as a great wave; and, to understand the phenomena of the tide-wave, it is necessary to have some other wave as its type. No wave, presenting any analogy to the tide-wave, or furnishing any explanation of it, was known to philosophers, until the researches of Mr. Scott Russell brought to light what he has called the "Wave of the First Order, or Great Wave of Translation." He found in this wave a phenomenon which, like the tide, extends to the very bottom of the fluid—which, like it, gives to the waters a motion of translation, which is uniform to great depths. He ascertained by experiment, that in shallow water, at least, the tide-wave moves with a velocity equal to that of the wave of the first order, being the same velocity which a heavy body, falling freely by gravity, would acquire in descending through half the depth of fluid. This wave of the first order is, therefore, that phenomenon which presents the closest analogy to the tide-wave, and may be taken to some extent as its type, especially as it approaches our shores or ascends our rivers, and where, no longer obeying the influence of planetary attractions, but subject to the laws of pressure and motion of fluids, it is now diverted one way, and now another, according to the forms of the shore, and the undulations of the bottom of the sea. Dr. Whewell, in his paper of 1833, made use of a hypothesis of this kind for the construction of his *Cotidal Lines*, and has since re-constructed them, especially in the German Sea, on various modifications of it. In the Map of the British Seas, we have given to the ridge of the tide-wave that form which would most nearly coincide with what has been observed of the motion of the wave of the first order—the only form by which at present we are able to guide our researches. The following is a table showing the velocity of the tide wave, considered as a wave of the first order, in different depths of the sea:—

1 fathom,	8 miles an hour.
10 ,,	25 ,,
20 ,,	36 ,,
30 ,,	44 ,,
40 ,,	51 ,,
50 ,,	57 ,,
60 ,,	63 ,,
70 ,,	65 ,,
80 ,,	73 ,,
90 ,,	77 ,,
100 ,,	80 ,,
200 ,,	114 ,,
400 ,,	160 ,,
1,000 ,,	250 ,,
4,000 ,,	500 ,,

The Tidal Chart of the British Isles has, for its object, to show the manner in which the single tide-wave, arriving from the Atlantic on the south-western extremities of the British Islands, brings high-water successively to the harbours and rivers on the coasts of those seas, at periods of time ranging over twenty-four hours, and moving in various directions through every point of the compass. One great wave, thirty-nine hours old, is seen approaching the British Islands from the Atlantic, and, proceeding in a north-eastern direction, strikes on the south-western promontories of France, near Brest; of England, off Falmouth; and of Ireland, off Cape Clear. This we have marked IV., as occurring at four o'clock on the third day of the tide's age, Greenwich time. Following this tide up the English Channel, we find it carry high-water nearly simultaneously along the southern coast of England, and the opposite coast of France; passing the Strait of Dover after ten, proceeding in a northerly and easterly direction along the coast of the Netherlands and Germany; while the other extremity of the wave, passing northerly in the German Sea with a much smaller intensity, from the obliquity of its incidence on that coast, modifies the phenomenon, but does not, except in singular cases, rule the hours of high-water on the east of England and Scotland, which are due most directly to the other or northern wave, which we have yet to examine.

Returning to the Land's End in Cornwall, which separates the English from the Irish Channel, we find the great Atlantic wave entering the wide funnel mouth of the Severn, where it finds a slowly shelving and nearly uniformly sloping bottom, which raises it to the great height for which that channel is distinguished. Passing northerly, and still with its easterly direction, it enters the basin of the Irish Sea, and brings high-water to the whole west of England shore, and, meeting another branch of the Atlantic wave that has come in between the north of Ireland and south-west of Scotland, spreads high-water over all the shores that surround the Isle of Man.

Meanwhile, the extreme northern limb of the great Atlantic wave encounters the Western Islands and Highlands of Scotland, and, passing rapidly round in the depths of the Northern Ocean, enters, at VIII., the northern extremity of the German Sea, giving high-water nearly simultaneously to opposite coasts of Scotland and Norway. Aberdeen receives it near the end of the second day, and, pursuing its course along the coasts of England and Scotland, on which it strikes very directly and with great force, it rules the tides as far south as the Thames and the Nore. It now determines also the tides of Belgium, from Ostend to Dunkirk, and does not cease to affect, though it does not rule, the tides of the Continent through the Channel.

It will be observed how much the *figure of the shores*, and the *form of the bottom*, and the *direction of incidence of the tidal wave*, affect the *height* of the tide. The whole range of the Atlantic tide, even at ordinary springs, does not exceed ten or twelve feet in open and deep sea. It reaches the south-west of Ireland nearly unchanged. On entering the German Sea on the north of Scotland, it does not exceed twelve feet, but gradually increases to fourteen, sixteen, eighteen, and in the Humber to twenty feet, as it travels along a shore continually shelving, and which it strikes with constantly diminishing obliquity. In the same way, a slowly shelving bottom and oblique shore at Bristol, and at Liverpool, and at St. Neots, raise the tide to a range even of thirty feet. The smallness of the tides at Portland Bill, at Wexford and Wicklow, at Rathlin, and at Yarmouth, shows either the great obliquity of such coasts to the direction of incidence of the tide-wave, or the interference of a high-water with a low-water, when there are two waves concerned in the phenomena. This latter may be the case at Yarmouth and Rathlin; it is less probable at the other places named, where the form of the coasts and bottom of the sea divert the tide in another direction. We have already noticed, that an interval of about two days appears to elapse between the date of the genesis of the tides in the Antarctic Sea, and the epoch of the corresponding high-water at London; this quantity varies with the moon's age, and has been called the *semi-menstrual inequality* in the time of high-water. The height of the tide varies in a similar manner with the moon's age, forming what is also called the semi-menstrual inequality in height. The nature of these variations are sufficiently illustrated by the following examples, which we select as the most instructive. They have been constructed under the direction of Sir John W. Lubbock, and are taken from the very remarkable series of discussions, forming the subject of his valuable papers in the "Philosophical Transactions."

Table I.—Showing the semi-menstrual inequality + a constant in the interval between the moon's transit and the time of high-water, with reference to the apparent solar time of the moon's transit B, the moon's parallax being 57′, her declination 15°, the sun's parallax 8″·8, and declination 15°.

Moon's Transit B		Brest Harbour.			Plymouth Dock-yard.			Portsmouth Dock-yard			Sheerness Dock-yard.			London Docks			Pembroke Dock-yard.			Bristol Cumberland Gates.			Liverpool Docks.			Howth Harbour.			Leith Docks.			Moon's Transit B.	
H.	M.	D.	H.	M.	D.	H.	M.	D.	H.	M.	D.	H.	M.	D.	H.	M.	D.	H.	M.	D.	H.	M.	D.	H.	M.	D.	H.	M.	D.	H.	M.	H.	M.
0	0	1	4	27	1	6	12	1	12	21	2	1	48	2	3	16	1	6	42	1	7	53	1	12	2	1	11	43	1	15	15	0	0
0	30	1	4	18	1	6	5	1	12	13	2	1	40	2	3	7	1	6	35	1	7	45	1	11	51	1	11	32	1	15	8	0	30
1	0	1	4	11	1	5	56	1	12	6	2	1	32	2	2	59	1	6	27	1	7	36	1	11	46	1	11	22	1	15	0	1	0
1	30	1	4	3	1	5	47	1	11	58	2	1	24	2	2	51	1	6	20	1	7	29	1	11	40	1	11	13	1	14	53	1	30
2	0	1	3	56	1	5	38	1	11	50	2	1	16	2	2	43	1	6	12	1	7	19	1	11	33	1	11	5	1	14	47	2	0
2	30	1	3	48	1	5	29	1	11	43	2	1	10	2	2	36	1	6	6	1	7	12	1	11	27	1	11	0	1	14	40	2	30
3	0	1	3	43	1	5	20	1	11	37	2	1	4	2	2	30	1	6	1	1	7	4	1	11	22	1	10	53	1	14	36	3	0
3	30	1	3	40	1	5	12	1	11	33	2	1	0	2	2	26	1	5	56	1	6	56	1	11	17	1	10	58	1	14	34	3	30
4	0	1	3	39	1	5	6	1	11	30	2	0	58	2	2	24	1	5	52	1	6	48	1	11	14	1	11	0	1	14	34	4	0
4	30	1	3	40	1	5	3	1	11	30	2	0	57	2	2	24	1	5	50	1	6	44	1	11	14	1	11	2	1	14	37	4	30
5	0	1	3	33	1	5	1	1	11	33	2	1	3	2	2	29	1	5	49	1	6	43	1	11	17	1	11	7	1	14	43	5	0
5	30	1	3	51	1	5	4	1	11	40	2	1	11	2	2	38	1	5	54	1	6	47	1	11	27	1	11	16	1	14	56	5	30
6	0	1	4	3	1	5	14	1	11	55	2	1	26	2	2	56	1	6	5	1	6	55	1	11	43	1	11	25	1	15	13	6	0
6	30	1	4	18	1	5	31	1	12	12	2	1	44	2	3	11	1	6	18	1	7	10	1	12	0	1	11	40	1	15	30	6	30
7	0	1	4	32	1	5	52	1	12	25	2	1	59	2	3	27	1	6	37	1	7	35	1	12	15	1	11	55	1	15	42	7	0
7	30	1	4	43	1	6	9	1	12	37	2	2	16	2	3	42	1	6	54	1	7	57	1	12	28	1	12	10	1	15	53	7	30
8	0	1	4	52	1	6	22	1	12	47	2	2	22	2	3	50	1	7	2	1	8	9	1	12	36	1	12	19	1	15	58	8	0
8	30	1	4	58	1	6	31	1	12	51	2	2	27	2	3	53	1	7	9	1	8	14	1	12	40	1	12	22	1	15	57	8	30
9	0	1	4	59	1	6	36	1	12	53	2	2	25	2	3	52	1	7	12	1	8	16	1	12	40	1	12	24	1	15	55	9	0
9	30	1	4	57	1	6	36	1	12	50	2	2	23	2	3	50	1	7	11	1	8	16	1	12	38	1	12	22	1	15	52	9	30
10	0	1	4	53	1	6	34	1	12	46	2	2	18	2	3	45	1	7	10	1	8	14	1	12	33	1	12	18	1	15	47	10	0
10	30	1	4	48	1	6	30	1	12	40	2	2	12	2	3	38	1	7	4	1	8	11	1	12	26	1	12	12	1	15	40	10	30
11	0	1	4	40	1	6	24	1	12	33	2	2	4	2	3	31	1	6	57	1	8	6	1	12	20	1	12	3	1	15	33	11	0
11	30	1	4	33	1	6	19	1	12	27	2	1	57	2	3	23	1	6	48	1	8	0	1	12	10	1	11	53	1	15	24	11	30

Table II.—Showing the semi-menstrual inequality + a constant in the height of high-water, with reference to the apparent solar time of the moon's transit B, the moon's parallax being 57′, her declination 15°, the sun's parallax 8″·8, and declination 15°. (*Empirical.*)

Moon's Transit. B		Plymouth Dock-yard.	Portsmouth Dock-yard.	Sheerness Dock-yard.	London Docks.	Pembroke Dock-yard.	Bristol Cumberland Gates.	Liverpool Docks.	Leith Docks.	Moon's Transit B.	
H.	M.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	H.	M.
0	0	17·67	19·09	25·63	22·71	22·77	32·23	17·57	16·29	0	0
0	30	17·65	19·05	25·56	22·72	22·73	32·25	17·62	16·18	0	30
1	0	17·72	18·97	25·50	22·58	22·55	32·16	17·50	16·00	1	0
1	30	17·58	18·82	25·33	22·44	22·25	31·77	17·17	15·78	1	30
2	0	17·38	18·62	25·15	22·18	21·86	31·08	16·75	15·54	2	0
2	30	17·10	18·46	24·92	21·92	21·37	30·25	16·30	15·25	2	30
3	0	16·75	18·25	24·65	21·53	20·84	29·38	15·73	14·88	3	0
3	30	16·37	18·00	24·25	21·14	20·21	28·20	15·10	14·42	3	30
4	0	15·99	17·71	23.86	20·68	19·54	26·82	14·37	13·92	4	0
4	30	15·50	17·45	23·50	20·23	18·88	25·27	13·65	13·46	4	30
5	0	15·04	17·12	23·20	19·90	18·11	23·91	13·05	13·05	5	0
5	30	14.70	16·96	23·00	19·57	17·67	22·53	12·65	12·73	5	30
6	0	14·52	16·69	22·96	19·56	17·40	21·72	12·40	12·58	6	0
6	30	14·46	16·65	23·08	19·55	17·29	21·73	12·32	12·67	6	30
7	0	14·63	16·83	23·31	19·84	17·46	22·39	12·55	12·67	7	0
7	30	15·00	17·16	23·64	20·28	17·92	23·88	13·10	13·21	7	30
8	0	15·50	17·49	23·94	20·71	18·71	25·25	13·86	13·60	8	0
8	30	16·00	17·79	24·27	21·15	19·50	26·60	14·55	14·08	8	30
9	0	16·42	18·11	24·58	21·52	20·12	27·90	15·20	14·61	9	0
9	30	16·82	18·37	24·92	21·89	20·75	29·00	15·80	15·14	9	30
10	0	17·12	18·58	25·20	22·15	21·29	30·00	16·35	15·59	10	0
10	30	17·42	18·75	25·42	22·42	21·83	30·77	16·65	15·92	10	30
11	0	17.67	18·90	25·58	22·56	22·27	31·50	17·20	16·18	11	0
11	30	17·82	19.03	25·63	22·70	22·60	32·05	17·45	16·30	11	30

The *height* in Table II. is reckoned as follows:—

At Plymouth, from a mark which is two feet above the sill of the north New Dock gates; at Portsmouth, from the sill of the North Dock gates; at Sheerness, from the entrance of the Basin, thirty-one feet below Lloyd's standard mark (+ XXXI.) on the quay; at the London Docks, from the sill of the gates at the Wapping entrance; at Pembroke, from the marks cut in the stone at the entrance of the dock; at Bristol, from the marks at the Cumberland Gates; at Liverpool, from the datum on the east wall of the Canning Dock; at Leith, from the sill at the entrance of the docks.

In the Nautical Almanac, Admiral Beaufort inserts a very full table of the times of high-water at different points all over the world. The reader may also consult with advantage the articles on tides in the Encyclopædias Britannica and Metropolitana; the series of researches in the Philosophical Transactions since 1831; and an Elementary Treatise on the Tides, by Sir John W. Lubbock, 1839. Here he will find the astronomical elements of tidal fluctuation fully discussed; a portion of the subject which is of the first importance, but is not appropriate to these brief notes on the terrestrial distribution merely of phenomena, the primary causes of which must be sought for out of the region of these little maps.

THE RIVER SYSTEMS OF EUROPE AND ASIA,

SHOWING

THE BOUNDARIES AND COMPARATIVE EXTENT OF THE RIVER BASINS, AND THE SEAS TO WHICH THEY CONTRIBUTE THEIR WATERS.

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INTRODUCTION.

Great rivers are the bonds of union which unite the people of different tribes or countries; and if they terminate in the ocean, they form an important link in the chain of the physical phenomena which tend to the improvement of the social life of man. In this respect the countries of Europe as well as those of Southern and Eastern Asia are highly favoured, whilst Northern Asia has no such advantages; for although its river systems are so extensive as to rank amongst the greatest in the world, yet the climatic element interposes to destroy their usefulness. The mouths of the Oby, the Yenesei, and the Lena, are almost constantly covered with ice. Hence Northern Asia can take no part in the commerce of the world, from which also Central Asia, or the district of the continental streams, is excluded.

Rivers are currents of water flowing through the land in open channels; they are formed from the accumulated waters of brooks and rivulets, which originate generally in springs; and these latter have their origin in the precipitation which falls from the clouds in the form of rain and snow, and this precipitation is the condensed vapour which is raised from the surface of the earth by the action of heat. There is thus a continual interchange between the earth and its atmospheric covering; for what the earth contributes to the atmosphere in the form of vapour is returned as rain or snow.

EXPLANATION OF THE MAP.

In order to present a connected view of the river systems of the northern part of the Old World, we have here, as in the map of the Mountain Chains, considered Europe as a peninsular prolongation of Asia. We have thus been enabled to indicate the comparative size of the areas of river basins, and the slope of the countries toward the seas into which the rivers discharge themselves. This form of construction was also necessary for the representation of the great central plateau, which forms the basin of the continental streams.

I. OCEANIC RIVERS.

The oceanic streams of Europe and Asia contribute their waters to four different seas, and these are distinguished by different colours on the map. From which it appears that the rivers of Europe empty themselves chiefly into the Atlantic Ocean and its branches; those of Southern Asia flow exclusively into the Indian Ocean; those of Eastern Asia, into the Pacific Ocean; and those of Northern Asia, into the Arctic Sea, to which also Northern Europe contributes its waters.

Hence it appears, that the principal rivers of Europe flow generally in a north-west and south-east direction, indicating the two great declivities of this quarter of the globe occasioned by the form of its mountain regions. The great northern declivity of Asia extends northwards from the basin of the continental streams to the Arctic Ocean, and in a direction from east to west, between the Ural Mountains and the Pacific Ocean; the southern declivity carries all the waters south of the Himalayan Mountains and the Caucasus to the Indian Ocean and the Persian Gulf; the eastern declivity is indicated by the rivers which flow to the Pacific Ocean and the China Sea; and the western by those flowing from the west of the Bolor Mountains.

II. CONTINENTAL RIVERS.

These occupy the centre of the Map, and their Basins are Shaded *with Points.*

The basin of the continental streams, as we have termed it, commencing near the Gulf of Finland and the Black Sea, extends eastward through the whole of Inner Asia, nearly to the Yellow Sea, comprising an extent of more than three millions of imperial square miles. This district, besides the numerous rivulets of the steppes, and many extensive lakes, contains the Volga, the principal river of Europe, and the Caspian Sea, the greatest lake in the world. There is thus a remarkable distinction between the oceanic and the continental streams; the rivers of Inner Asia, and a great part of Eastern Europe, do not immediately reach the sea; many extensive streams are confined exclusively to the continent, sometimes discharging themselves into lakes, and at others, though more rarely, they are lost in the sands of their own channels.

III. RIVER BASINS.

The basins of the different rivers in each of the ocean districts are separated by dotted lines. These lines represent the watershed, and consequently indicate the highest land of a river basin, the lowest part of which is occupied by the main stream. The figures placed above the name of the river show the extent of the basin in square miles; those below the name, its extent as compared with the district of the Pregel, which is shaded by dark lines on the map. This district, which is assumed as unity, is of nearly equal extent with that of the Severn in England, which is similarly shaded on the map.

HYDROLOGICAL EXPLANATIONS REGARDING RIVERS.

I. BASINS.

The entire sources, brooks, and rivulets, whose waters contribute to the formation of a river, from its source to its termination, or the surface of the country which is drained by it, form its district or basin. This definition applies to every river, whether principal or affluent; thus river basins vary in size from the district of the smallest brook to that of a main stream or principal river. The size of a river basin depends, in general, on the extent of the continent or quarter of the earth to which it belongs.

Europe, which, next to Australia, is the smallest division of the earth, possesses the smallest river districts; America and Asia the largest.

II. WATERSHED AND PORTAGE.

The place whence flowing waters begin to descend in opposite directions is called the *watershed.* This marks the limit of the river basin, and forms a line either along the declivities of mountains or in plains. In the latter case the watershed is often so flat that barges can be easily conveyed over the country which separates the different river basins; and those places which are most suitable for this purpose, or for being united by means of canals, are called *portages.*

III. BIFURCATION.

Mountains and watersheds are not, as has been erroneously assumed, the same. Mountains have often, in proportion to their size and extent, only a very unimportant influence on the form and direction of watersheds; and there are cases, for example, in North America, where opposite river basins have their origin in lakes. And, contrary to the prevailing opinion, it is now found that opposite river basins are sometimes connected by natural water courses, in consequence of such a depression of the surface of a country as permits the water of a river, after being diverted from its proper channel, to join another river with which it is otherwise unconnected. The most remarkable phenomenon of this kind, which is called the *bifurcation* of a river, occurs in the basin of the Orinoco.[1]

IV. SIZE AND LENGTH OF RIVERS.

The importance of a river is estimated by the length of its course; but in this the direct distance from the source to the mouth must be distinguished from that which includes the windings which it describes. From a comparison of both values is deduced the length of the river course, which is the more important the shorter the direct distance is from the source to the mouth, and the more numerous its windings. This is more especially the case if the river be navigable through a great part of its course.

The quantity of water in a river increases, generally, with the size of its district or basin, and the number of affluents which contribute to its formation; hence, in general, rivers have the greatest amount of water at their mouths, or towards the end of their course. The amount of water in a river varies with the seasons, and depends in some cases on the extent of the atmospheric deposition, in others on the melting of snow; thence on the state of heat, and in all cases on meteorological and climatic conditions.

Rivers are not extensive in proportion to the elevation of their sources, as was formerly supposed; for the Volga, the largest of European rivers, rises at a height of only 550 feet above the level of the sea. But the greater number of large rivers have their origin in high mountains, or elevated tablelands.

V. RIVER COURSES.

Three degrees of development are observed during the progress of a river from its source to its termination, viz., the upper, the middle, and the lower course; and these may be, according to circumstances, more or less fully recognised.

In their *upper course,* rivers flow in channels inclined to the horizon; and in descending the declivities of mountains, the bed of the current forms a narrow gorge confined by high and steep rocky sides, between which the water flows, or rather rushes, from the steep declivities in foaming cataracts and cascades. Such is the character of the upper course of streams which have their origin in high mountains, and before changing this they usually form waterfalls, which mark the transition to the *middle course.* In this, the middle course, the declivity of the river bed is less rapid, the stream flows over a comparatively level or hilly country, the channel is broader, and instead of the sharp angular lines of the upper course, the river describes rounded bends, and serpentine meanderings, and its low banks are sometimes broken through by the force of the mass of water, which finds for itself a new channel.

VI. DELTAS.

If the middle course of a river be enclosed by a mountain chain, it must force its way through, in order to reach the lower course. In this transition, the appearances of the upper course are repeated, although on a smaller scale. The bed of the stream contracts, and produces the phenomenon of rapids. Here the *lower course* begins: the river now flows generally through a plain, the current is very slow, the declivity of its bed being almost imperceptible; and towards its termination it is characterized by the efforts of the water to divide and ramify, imparting to the regions of its mouth the form which, from its resemblance to the Greek letter Δ, is called the *delta* land of the river. This is caused by the solid matter brought by the river being deposited, and filling up a former bay of the sea, or by a natural obstacle, which divides the stream into two or more branches. But this form of the mouth is not general; some streams discharge themselves into a bay, which, in this case, is called a negative delta; or they find an outlet in a lake-like extension or lagoon, which, separated from the sea by downs, has a very narrow channel, at the mouth of which is usually a bar or shoal. Others, again, discharge themselves at once into the sea, when their currents may be traced to a great distance from the shore. Deltas are *fluviatile* when formed at the entrance of one river into another; *lacustrine,* when at the embouchure of a river into a lake; and *maritime* when the river falls into the sea. Within the deltic branches there are frequently many other diverging and anastomosing branches, which, for distinction's sake, may be called ana-deltic, and which cut up the delta into a greater or less number of deltic islands.[1]

VII. VELOCITY OF RIVERS.

The velocity of a river depends on the form of the channel, its inclination, and the volume of water contained in it. If the water met with no resistance from its banks, the velocity of a river would depend upon the accelerating force of gravity, which would soon become so great as to render it the instrument of devastation and ruin over its whole course. The Thames, which has a descent of only one hundred feet, would then flow at the rate of fifty-four miles an hour; and the Rhone, which receives the great body of its waters at an elevation of nine hundred feet, would acquire at its mouth a velocity of one hundred and sixty-four miles an hour. The molecules of water in contact with the sides and bottom of the channel, being retarded by friction, move more slowly than those at the surface and centre; and hence, the greatest velocity of a river, flowing in an open channel, is in the middle of the current; and in consequence of the pressure of the upper stratum of water tending to give greater velocity to that which is under it, this maximum is found at a little depth below the surface. The greatest velocity is to the mean velocity nearly in the proportion of five to four. Thus, if the greatest velocity is determined by experiment, the mean may be assumed at four-fifths of the amount nearly.

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[1] See River Basins of South America, Plate 17, p. 57.

[1] See valuable "Hints on the Subject of Geographical Arrangement and Nomenclature," Journal of the Royal Geographical Society, vol. iv., p. 72.

VIII. DEVELOPMENT OF RIVERS.

The length of a river, from its source to its mouth, including all its windings and turnings, is called its development. If we compare this development with the direct distance between the source and the mouth, we ascertain the amount of the windings, and thus arrive at a scale for determining the influence which the river exercises on its district. In order to this we have to consider not only the length of the principal channel, but also the surface extent of all its tributary channels. These, in reference to the horizontal extent of the rivers of Europe and Asia, are given in a table below, in which all the data are quoted which can be expressed in figures.

HYDROGRAPHIC TABLE OF EUROPE AND ASIA.

⁂ From the present defective state of Hydrographic knowledge, this table must be considered as giving only approximate results.

Names of Rivers.	Extent of River Basins in Geographical square miles.	Direct Distance of Rivers from Source to Mouth in Geographical Miles.	Extent of Development of Streams, in Geographical Miles.	Extent of Windings of Streams, in Geographical Miles.	Proportion of Windings to Direct Distance of Rivers.
		Geographical Miles 60 to a Degree.			
Atlantic System.					
Neva,	47,200?	315?	440?	128	0.4
Rhine (Rhein)	65,280	360	600	240	0.6
Vistula,	56,640	280	520	240	0.8
Elbe,	41,860	344	684	340	1.0
Oder,	39,040	280	480	200	0.7
Loire,	33,040	320	520	200	0.6
Duna or Dwina,	32,440	280	560	280	1.0
Niemen,	32,180	240	460	220	0.9
Duero or Douro,	29,230	260	440	180	0.7
Garonne,	24,450	200	320	120	0.6
Seine,	22,620	220	340	120	0.5
Tagus,	21,760	300	400	100	0.3
Guadiana,	19,300	240	420	180	0.7
Guadalquiver,	15,640	180	260	80	0.4
Weser,	13,120	200	280	80	0.4
Minho,	11,840	136	192	56	0.4
Pregel,	5,020	60	100	40	0.7
Mediterranean System.					
Nile,	520,200?	1,320?	2,240?	920	0.7
Po,	29,300	232	352	120	0.5
Rhone,	28,160	248	560	312	1.7
Ebro,	25,190	268	420	152	0.5
Euxine System.					
Danube (Donau),	234,080	880	1,496	616	0.7
Dnieper,	169,680	548	1,080	532	1.0
Don,	168,420	408	960	552	1.3
Dniester,	23,040	360	440	80	0.2
Arctic System.					
Obi,	924,800	1,276	2,320	1,044	0.8
Yenesei,	784,520	1,228	2,800	1,572	1.2
Lena,	594,400	1,336	2,400	1,064	0.7
Kolyma,	107,200	440	648	208	0.4
Dwina,	106,400	380	864	484	1.3
Indigirka,	86,400?	560?	808?	248	0.5
Olenek,	76,800	600	1,000	400	0.7
Anadir,	63,360?	. . .	. . .	. . .	. .
Petchora,	48,800	360	600	240	0.7
Mesen,	39,520?	. .	. .	. .	. .
Continental System.					
Volga } Caspian Sea,	397,460	960	2,400	1,440	2.4
Oural } Caspian Sea,	83,200	350?	. . .	. . .	. .
Kour } Caspian Sea,	64,640	320	640	320	1.0
Sir or Sihon } Aral Sea,	237,920?	690	1,200?	448?	0.6
Amou or Gihon } Aral Sea,	180,000	816	1,400	584	0.7
District of Lob Lake,	177,120	622	1,000	378	0.5
Pacific System.					
Amoor,	582,880	1,200	2,360	1,160	0.9
Yang-tse-Kiang,	547,800	1,528	2,880	1,352	0.8
Hoang-Ho,	537,400	1,130	2,280	1,150	1.0
Tche-Kiang,	89,300	480	960	480	1.0
System of Indian Ocean.					
Ganges (including the Basin of the Bramahpootra),	432,480	824	1,680	856	1.0
Indus,	312,000?	936?	1,800?	864	0.8
Menam,	216,000?	620?	940?	320	0.5
Burrampooter,	159,680	600	1,492	892	1.5
Godavery,	92,800	540	748	208	0.4
Kistna,	81,600	440	668	228	0.5
Irawady,	331,200?	1,100	2,200	1,028	0.9

REMARKS.—From this table many instructive comparisons may be made.

For example, the direct length of the Vistula, from its source to its mouth, is 280 miles, and the development of the stream requires a course of 520 miles. The meanderings thus occupy 240 miles, or nearly nine-tenths of the direct distance, thus indicating the great amount of irrigation which this river communicates to its district. Again, the direct distance of the Rhine, from its source to its mouth, is shown to be 360 miles, or 80 miles more than the Vistula; the development of its course is 600 miles, also 80 miles greater than the Vistula; but the proportion of its windings amounts to only two-thirds of its direct course; the windings are therefore less than those of the Vistula, notwithstanding that the district of the former is much greater than that of the latter river. These comparisons may be extended to all the other river systems.

Reckoning the whole running waters of Europe = 1.00, we find the proportion for those rivers which discharge themselves into the different seas to be as follows:—

Black Sea	0.27 parts.
Caspian Sea	0.16 "
Mediterranean	0.14 "
Atlantic Ocean, about	0.13 "
Baltic Sea	0.13 "
German Ocean	0.11 "
Arctic Sea, about	0.06 "

This shows that the greatest amount of water is carried to the Black Sea, since it engulfs nearly the third part of all the running water of Europe. Again, nearly one-half of the whole running water of Europe falls into the Black and the Caspian Seas; which is the more remarkable as the one is an inland sea, situated in the interior of the continent, and the other a completely enclosed inland lake.

Comparing the river systems of Europe among themselves, we find, for the six largest, the following results:—Assuming the whole rivers of Europe = 1.00, the

Volga discharges thereof	0.14 parts.
Danube	0.12 "
Dnieper	0.06 "
Don	0.05 "
Rhine	0.03 "
Dwina	0.02 "

From this it appears that the Volga alone carries off as much water as the Mediterranean receives from Europe; that the waters of the Danube are almost as considerable as those of all the rivers which empty themselves into the Baltic Sea, &c.

COMPARATIVE VIEW OF THE FALL OF SOME OF THE PRINCIPAL RIVERS AND POSITIONS OF THE MOST REMARKABLE LAKES, WITH REFERENCE TO THE MEAN LEVEL OF THE SEA.

On the under part of the plate we have given sections of the elevations of the rivers Volga, Ganges, Danube, Elbe, Rhine, Rhone, and Clyde, at different parts of their course, from their source to their termination. These profiles are coloured to correspond with the ocean districts on the map—the elevations are measured from the vertical scale of English feet on the left side of the diagram, and the lengths from the horizontal scale of miles at the foot.

The Volga, the longest and the most level of the rivers here represented, has its origin in a small lake on the slopes of the plateau of Valdai, at an elevation of about 550 feet above the level of the ocean,[1] whence it flows in a gently inclined bed to its termination in the Caspian Sea, 83 feet below the level of the Euxine. Its entire fall, over a course of more than 2400 miles, therefore, amounts to only 633 feet.

The Ganges, the source of which, in striking contrast with the Volga, is placed at the highest point of the diagram, issues from the southern slopes of the Himalaya Mountains, at an elevation (reckoning from the point where the Bhagirathi source springs from under the glacier) of 13,800 feet. It falls rapidly to Hurdwar, where it enters the great plain of Hindostan, and thence flows with a smooth current to the ocean, which it enters by numerous mouths in the Bay of Bengal.

The Danube.—This celebrated river originates in the Brege, a mountain torrent on the eastern declivity of the Schwarzwald, at an elevation of 2850 feet above the level of the sea. This stream is afterwards joined by the Brigach, and by the waters of a spring from the castle garden at Donaueschingen, in the Duchy of Baden, when the united stream takes the name of Donau or Danube. From this point it runs through an alpine country to Ulm, thence to Passau it traverses the plain of Bavaria. From Passau to Vienna it runs through a second hilly region, and the remainder of its course is generally through a flat country, except on approaching the rocky defile of the "Iron Gate," till it reaches its destination in the Black Sea. The section of the Danube on the boundaries of Germany and Hungary shows a remarkable coincidence with that of the Ganges at Allahabad, in the lowlands of Hindostan.

The Elbe rises in the western slopes of the Schnee-Koppe, in the Riesengebirge and the neighbouring mountains, from upwards of 30 springs, the southernmost of which, the *Elb-brunnen*, is situated at the elevation of 4500 feet. The navigation of this important river is much impeded by the lowness of its bed, the greater part of its course, as shown on the diagram, being only from 150 to 300 feet above the level of the sea; and its estuary, at Cuxhaven, is encumbered with sand-banks.

The Rhine originates in two streams of the same name—the *Hinter* and *Vorder Rhein*. The first springs from the Rheinwald Glacier between Portahorn and St. Bernardin, and after a north-east course of about 35 miles it joins the Vorder Rhein at Reichenau. The Vorder Rhein springs, under the name of the Rhein de Toma, on the north side of the St. Gothard, at a height of 7650 feet; it has a rapid declivity to the Boden See, (Lake of Constance), the elevation of which is only 1250 feet; and after forming the celebrated falls of Laufen, the division of the Upper Rhine terminates at Basel, with an elevation of upwards of 800 feet. The lower course of this important river is navigable from Basel to the German Ocean, and its delta is larger than that of any other European river.

The Rhone has its source in the Rhone Glacier on the west side of the St. Gothard, between the Furka, Galenstock, and Grimsel, at an elevation of 5500 feet above the level of the sea. Rising in the same mountainous country, although flowing in an opposite direction, the upper part of its course bears a striking resemblance to that of the Rhine; and the lakes of Geneva and Constance, which are formed at nearly a corresponding distance from the sources of the Rhone and the Rhine, differ only by about 200 feet in elevation. But the under course of the Rhone has a much greater declivity than that of the Rhine; for while at St. Genis the former is still 640 feet above the sea, the latter, at a corresponding distance from its mouth, namely, at Mannheim, is less than 300 feet. The Rhone has consequently a much more rapid course than the Rhine; it enters the Mediterranean by two principal mouths.

The Clyde, the only important river on the western coast of Scotland, rises in the range of mountains which separate the southern extremity of Lanarkshire from the counties of Dumfries and Peebles, at an elevation of 1400 feet. Near Lanark it is precipitated over a series of highly picturesque falls, after which it flows over a gently inclined bed to the vicinity of Glasgow, whence it has been made navigable to its embouchure in the Firth of Clyde.

POSITIONS OF THE MOST REMARKABLE LAKES ABOVE AND BELOW THE LEVEL OF THE SEA.

These are placed simply in the order of their importance as regards elevation, on the right side of the diagram; and measured, as in the case of rivers, from the scale of feet on the left. The highest point on the scale represents Lake Sir-i-Kol, and the lowest the Dead Sea; between these two points there is a space of nearly 17,000 feet, a portion of which is occupied by the relative positions of some of the best known lakes in different parts of the globe. Lake Sir-i-Kol, whence issues the River Oxus, is situated in the district of Pamir, at an elevation of 15,600 feet above the sea, as ascertained by Lieut. Wood, in his journey to the source of the River Oxus in 1838.

The Lake of Titicaca, in the table-land of Bolivia, is, according to Pentland, 12,847 feet above the level of the sea. The Trüb Lake in Switzerland has an elevation of 7200 feet, and even the small lake on Ben Nevis is upwards of 1800 feet, while Lake Superior is only 630 feet above the level of the sea. Descending below the level of the ocean, we find the Caspian Sea (the altitude of which has at last been so satisfactorily ascertained) depressed 83.6 feet below the level of the Black Sea. Still lower in the scale is the Lake of Tiberias, 328.98 feet, and lowest of all the Dead Sea, 1312.2 feet below the level of the Mediterranean. The exceedingly interesting fact of the amount of depression of this sea, which the barometrical measurements of Moore, Schubert, Russegger, and others left undecided, was finally ascertained by the geodetical operations of Lieutenant Symonds in 1841.

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[1] Müller gives an elevation of upwards of 800 feet, but this must be a mistake, since the mean height of the Valdai Hills is only 941 feet, and the lake is situated on the plateau considerably to the south of the range.—See *Humboldt's Asie Centrale*—Map in Vol. iii.

SALT LAKES OF CONTINENTAL BASINS, AND THEIR ORIGIN.

BY PROFESSOR H. D. ROGERS, BOSTON.

The insulation of the waters of the continental river-basins from those of the great ocean is plainly due to an equilibrium, in these regions, between the evaporation and the amount of water received from the atmosphere; and this equilibrium—or excess, it may be—of the evaporation over the supply, is obviously connected with the dryness of the prevailing winds, which, permitting little rain to fall, drink greedily back the chief portion of that which descends. Wherever high mountain-barriers, or even wide spaces of continent, interpose to chill and precipitate the moisture of the winds flowing in from the ocean, the regions beyond are in this condition of either partial or entire adjustment, between the remnant of water they get and the evaporation. The amount of moisture which reaches them, and remains upon the earth as water, is insufficient to fill and overflow the depressions of the surface, and maintain itself till it joins the sea. Those tracts which are swept across by winds excessively desiccated, receive and hold too little humidity to sustain vegetation; and hence all the arid deserts of the world, the positions of which are either far interior from the ocean, or insulated from the sea by lofty, continuous, and rain-collecting chains of mountains. Intermediate in degree of dryness between the completely "rainless districts," and those where there is a surplus of rain above evaporation to be discharged into the ocean, are those tracts of deficient rain which pour off none of the water which they collect. These are the true continental river-basins, and within their limits will be found, without exception, all the lakes and collections of water destitute of outlets, like the Caspian, the Sea of Aral, and the Dead Sea in Asia, and the Great Salt Lake of North America.

The basins thus insulated from the sea are invariably more or less saline, whereas outside of their limits, in the regions draining into the ocean, we nowhere meet with either salt lakes or plains covered with saline incrustations. The cause of this difference is obvious. In the closed basins, the saline matter which the infiltering rain is perpetually carrying off from the decomposing soil and the rocks, is collected and accumulated by the evaporation of the waters in these confined receptacles; whereas in the districts of open drainage it flows on with the streams into the sea. "Salt water" and "fresh water" are, in this view, but relative terms, for every brook and river is to some slight degree impregnated with the soluble constituents of the mineral crust of the globe, especially with the chlorides; and the only difference is, that the waters of the one class have been concentrated by evaporation, while the others are fresher from the clouds, and in their transit to receptacles where they are yet to undergo this concentration. Pursuing this generalisation, we perceive that the main ocean itself is only a larger Caspian or salt lake, supplied perpetually, like the rest, with accumulating salt, by a merely wider circle of indraining streams.

As the sedimentary strata are nearly all marine, it is obvious that the free salt which they invariably contain has been left in them by the ancient seas which have deposited and washed them; and it is this imprisoned salt, already in solution in the moisture of the sandstones and other strata, that undoubtedly furnishes the chief supply which the rains now take out from the earth, and the rivers bear forward to the ocean and to the salt lakes. But though derived secondarily from the ancient oceanic waters, this salt is to be traced primarily to the original igneous minerals and later volcanic ejections, to which geology traces alike both the soluble and the insoluble constituents of all the stratified deposits.

From the facts and general views here developed, it is easy to discern the origin of the beds of rock-salt, and the saline incrustations of the soil, so common in the basins of closed drainage. The plains immediately bordering the salt lakes—as those of the Caspian and the Utah Lake, for example—have become charged with crystallising salt, evidently through the gradual progressive shrinking of those sheets of briny water; but as this can only have proceeded through a parallel drying of the atmosphere of these insulated basins, we behold in every well-marked instance of this sort the unequivocal record of important climatal changes. These salt lakes, and their encircling saliferous plains, and the salt-incrusted deserts no less, are therefore but so many great hygrometric registers, whereby we learn not merely the present but antecedent conditions of equilibrium in the slowly-changing atmospheric balance of rain and evaporation.

As the geographical position of the salt lakes and saliferous plains is determined by that of the dry winds, of which they may be said to be a function, and as in the ancient strata—the products of former states of the earth's successive surfaces—there occur other accumulations of salt, which testify as unequivocally as these do, to the prevalence of a desiccating atmosphere, it is plain that, in the investigation of the distribution of those tertiary and secondary saliferous deposits, we have a new means of interpreting the ancient local climates of the globe. The earth's local climates have, however, been at all periods mainly controlled by the relations of the ocean to the lands, in reference to the great systematic winds, so that, in thus ascending, through a study of the geographical limits of the salt strata of the early geological epochs, to a perception of the special climatal conditions influencing those limits, we mount yet one step farther, and catch glimpses of the relative positions of the seas and lands of those ages, and possibly of the situation of the mountain barriers, which dried the winds, and endowed them with their evaporating or salt-collecting power.

The general laws here indicated as controlling the distribution of the existing salt lakes and basins, will be more intelligible if the reader will examine the position of the saliferous waters and plains on the charts of the river systems of Asia and Europe, and of America; and will then, by aid of the Map of the Perennial and Periodical Winds, and the Rain Map of the World, observe the special climatal conditions of the districts which embrace these receptacles of the accumulating salt. The saliferous deserts and plains of Northern Africa and of Asia lie just in that great zone of the eastern continent, where the winds are rainless, from having passed lofty chains of mountains in their progress inland, and it is in the semi-arid belt adjoining this girdle of deserts that we find the Dead Sea, the Caspian, the Sea of Aral, and many other salt lakes less prominently known. It will be seen that the annual supply of rain to these basins amounts to only a very few inches, so that it is fully balanced by the evaporation. The country of the Upper Volga, the great feeder of the Caspian, receives not more than 10 or 12 inches, and that of the Caspian itself much less. In South America, the salt plains of Peru and Bolivia lie all on the western side of the main chain of the Andes, which here interposes its colossal barrier to arrest the remnant of moisture left in the trade-wind after it has watered the great oceanic basin of the Amazon, from the Atlantic to their base. But farther south, along the same great wall, there is a reversal of this state of things; the winds are from the Pacific, and they discharge their load of humidity on the western slopes of the Andes, and the narrow plain between them and the sea, while the country east of the mountains, or Patagonia, is here the dry district, and is the district of saliferous plains, and of numerous salt lakes without outlets. Precisely similar is the relative position of the great continental basin of North America, in respect to the winds. Sheltered on the east by the Rocky Mountains from the breezes of the Atlantic, and from the humidity of the Pacific Ocean winds by the ranges of Oregon and California, it presents, on a grand scale, all the features consequent on this arrest of moisture, namely, great arid deserts, wide saliferous plains, beds of rock-salt, and drainless, closed lakes, strongly impregnated with salt.[1] The Salt Lake of Utah, situated near the eastern side of this vast basin, has its waters charged with some 22 per cent of salt,[2] and is bordered by large saline incrustations. And along the western side of the desert, and southward, in a like position, at the eastern base of the main Californian range, which cuts off the Pacific moisture, there exist many other analogous salt lakes and plains, shut in entirely from communication with the sea.

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[1] See Reports of Fremont and Stansbury.

[2] Stansbury.

THE RIVER SYSTEMS OF AMERICA,

SHOWING

THE BOUNDARIES AND COMPARATIVE EXTENT OF THE RIVER BASINS, AND THE SEAS AND LAKES TO WHICH THEY CONTRIBUTE THEIR WATERS.

INTRODUCTORY NOTE.

IN the notes to the preceding map it has been shown that the largest rivers in the Old World occur in Asia—the greatest and most connected mass of land on the globe; and in the present it will be found, that although the northern and southern portions of the New World are each much smaller in superficial area, they yet possess streams which, for the extent of their development, and the size of their basins, greatly surpass those of Asia.

America, indeed, has the greatest rivers on the surface of the globe; these and her lakes constitute her grandest natural features; and in them she possesses a medium of commercial intercourse unrivalled in the world.

An inspection of the maps of the physical features of North and South America will most readily explain the formation of the river basins, since the direction of river-courses depends on the orographical configuration of a country—the forms of great plains being determined by the slopes of the mountains, and those of secondary valleys by the more gentle declivities of the soil. Thus, while the greatest river of North America—the Missouri-Mississippi—confined on the west by the Rocky Mountains, and on the east by the Alleghanies—flows south to the Gulf of Mexico, the Marañon, rising on the western border of the southern continent, flows in an easterly direction to the Atlantic Ocean. From the peculiar formation of its mountain-chains, all the great rivers of America flow to the east, north, or south; and notwithstanding the immense development of its western coasts, no river of importance, except the Columbia, reaches the Pacific Ocean. Extending our views of the dependence of the hydrographical on the orographical peculiarities of countries, we shall find that by far the greater number of important rivers on the globe reach the ocean in an easterly direction; those which flow to the south and north being next in importance, while those having a westerly course are few in number, and comparatively insignificant in extent.

In the following brief notice of the principal basins into which this "land of waters" is divided, it will be observed that America presents many striking hydrological peculiarities, and furnishes ample opportunities for comparison with the corresponding phenomena of the Old World, to which our limited space will only admit of a passing allusion.

NORTH AMERICA.

The rivers of North America contribute their waters to the Atlantic, the Pacific, and the Arctic Oceans. The low watershed dividing the rivers which flow in a northern and north-eastern from those which flow in a southern direction, crosses the continent between latitude 40° and 50° north.[1] To the northward of this line is the Lawrentian Lake basin, or basin of the Great Lakes and of the St Lawrence river, presenting the greatest mass of fresh water on the surface of the globe. In consequence of the very slight elevation of the soil in these regions, natural communications are often established, during the rainy season, between rivers which flow in opposite directions, and the mouths of which are situated at a great distance from each other, as in the case of the junction of the branches of the upper Mississippi with the southern tributaries of Lake Winnipeg. And one of the principal tributaries of the Mississippi, the Illinois, is so nearly on a level with Lake Michigan, and so little separated from it by inequality of surface, that at the time of flood it is possible to sail from the one to the other. The abundance of water, and the lowness of the watershed, greatly favour the establishment of *portages*, without which it would be impossible to traverse this desolate region.

Basin of the Great Lakes and of the River St Lawrence.—The series of lakes sometimes called the "Canadian Sea," which lie to the south of Hudson Bay, forms a connected chain, extending in a direction from west to east, united by short river courses, or lake straits. The westernmost of these, *Lake Superior*, the largest fresh-water lake in the world, discharges itself through the River or Strait of St Mary, 50 miles long, into *Lake Huron*, into which also *Lake Michigan* pours its surplus waters, through the Strait of Mackinac, 40 miles in length. The waters of Lake Huron next pass by the River and Lake St Clair and the Detroit River, 25 miles long, into *Lake Erie*. This, the fourth link in the great chain, sends its surplus waters northwards, by the Niagara River, into *Lake Ontario*, forming, in its course of 33½ miles, the celebrated Falls of Niagara.

The River St Lawrence rises under the name of the St Louis, in latitude 47° 45′ north, longitude 92° west, and falls into the south-western extremity of Lake Superior. Quitting Lake Ontario at Kingston, it takes the name of the Iroquois, and flows in a north-easterly direction, forming, in its course, the wide expanses called Lake St Francis, Lake St Louis, and St Peter's Lake. It first takes the name of the St Lawrence after passing Montreal. Below Quebec it forms a broad estuary, and enters the Gulf of St Lawrence at Gaspé Point, by a mouth more than 100 miles in width. The basin of the St Lawrence is watered by many considerable streams, several of which fall into the different lakes; but no river of any importance flows into it from the South. As divided by the coloured space on the map, this vast basin is estimated to contain 297,600 square miles, of which, according to the following table, 94,000 square miles are covered with the water of the lakes alone:—

TABLE OF THE EXTENT, ELEVATION, AND DEPTH OF THE GREAT LAKES.

	Mean length in Miles.	Mean breadth in Miles.	Mean depth in feet.	Elevation above the level of the Sea in Feet.	Area in square Miles.
Lake Superior, ...	400	80	900	630	32,000
Green Bay, ...	100	20	500	578	2,000
Lake Michigan, ...	320	70	1,000	600	22,400
Lake Huron, ...	240	80	1,000	600	20,400
Lake St Clair, ...	20	18	20	570	360
Lake Erie, ...	240	38	120	565	9,600
Lake Ontario, ...	180	35	500	234	6,300
River St Lawrence, ...	.	.	20	.	940
			Aggregate, . . .		94,000

According to this estimate, the lakes occupy a surface larger than that of Great Britain, and contain 11,300 cubic miles of water, or more than half of all the fresh water on the globe. They are situated on four terraces differing in elevation, of which Lake Superior occupies the highest, and Lake Ontario the lowest point. The bed of these lakes forms the most remarkable depression in this part of the globe; for the bottom of Lake Ontario is 268 feet below the level of the Atlantic; whilst Lake Superior, with a mean depth of 900 feet, is elevated 630 feet above the Atlantic, at the surface, which gives to its bed a depression of 270 feet below the level of the sea.

Basin of the Missouri-Mississippi.—The Mississippi is the largest river of North America, and one of the greatest in the world. With its numerous tributaries, it occupies the whole of the southern portion of the great central basin which M. Balbi calls the plain of the *Mississippi-Mackenzie*. The course of the Mississippi forms such a regular succession of curves, that, in navigating it, the Indians were accustomed to calculate their progress by the number of bends they had passed. It issues from a small pool north of Lake Itaska, on the ridge of land dividing the waters which flow north to the Arctic Ocean, from those that flow south to the Gulf of Mexico, near latitude 47° 10′ north, longitude 95° west, at an elevation of 1680 feet above the sea. About 400 miles from its source it is precipitated over the *Falls of St Anthony*, forming a beautiful cataract 17 feet in descent. The *Missouri*, which drains the north-western angle of the basin, is the principal branch of the Mississippi, which it greatly surpasses in the length of its course and the volume of its waters, although it loses its name in the inferior stream; it rises in two branches on the eastern declivity of the Rocky Mountains, between 42° and 43° north latitude, within a mile or two of the sources of the Columbia, and, augmented by many great affluents, it joins the Mississippi after an estimated course of upwards of 3000 miles. The middle course of the Mississippi terminates at the mouth of the Missouri; from this point the course of the united stream is gentle, and little interrupted by islands. After receiving the waters of the Red River, it separates into two principal branches, the westernmost of which is the Atchafalaya, and the eastern the true Mississippi. (See map of the Delta.) These branches are subdivided by many smaller ones, which, with the former, constitute the delta of this great river, so remarkable for the number of its lakes and marshes. The Mississippi is navigable to the Falls of St Anthony, about 2240 miles from the sea. It falls into the Gulf of Mexico by several mouths, after a course of 3160 miles, measured along the course of the stream; but reckoning the Missouri as the principal branch, the whole course may be calculated at upwards of 4400 miles. The average fall of the Mississippi is 19 inches 87 hundredths per mile. (BACHE, Report of United States Survey.) The Missouri is navigable from the great falls in latitude 47° to the sea, a distance of 4000 miles; and it has been ascended by steam-boats 2200 miles from the Mississippi; but the highest point to which trading steamers ascend is to Council Bluff in Iowa. Among the many streams which fall into the Gulf of Mexico, on the west of the basin of the Mississippi, the Rio Colorado and the Rio del Norte are the chief; the latter rises in the Rocky Mountains, about latitude 38° 10′ north, longitude 106° 40′ west. It flows south-east, receiving as tributaries the Pecos, Chonchos, &c., and enters the Gulf of Mexico after a course of 2000 miles.

Basins of the Saskatchevan, Albany, Churchill, and Mackenzie.—The rivers whose basins are here enumerated, with some others less known on the east of Hudson Bay, occupy the northern declivity of the great central plain already noticed, and contribute their waters to the Arctic Ocean and Hudson Bay (or more properly, Hudson Sea). The whole region is covered with lakes, among which are the Winnipeg, one of the greatest lakes of America, Lakes Winnipegoos, Manitoba, Deer, Wollaston, Athabasca, Great Slave and Great Bear Lakes, all of which are of vast extent, besides a multitude of inferior lakes, and lake-like expansions of the rivers.

The *Saskatchevan River* rises with two branches in the Chippewyan or Rocky Mountains; these unite at about 450 miles from their sources, and at a distance of 650 miles the united stream falls into Lake Winnipeg, whence it issues, under the name of the Nelson River. This is the largest river which flows into Hudson Sea.

The *Churchill* or *Missinnippi River* is said to rise in Meythe Lake, but its sources are not sufficiently ascertained; it appears to communicate with Lake Wollaston by the Deer Lake, and thence enters the basin of the Mackenzie River.

The *Albany* has its source in Lake St Joseph, about 380 miles west from its mouth.

The *Severn* falls into Hudson Sea in latitude 56° north, but its origin is uncertain; some maps make its source in Lake Winnipeg.

The *Mackenzie* is the largest river which contributes its waters to the Arctic Ocean in the western hemisphere. It is formed by the union of several streams which rise on the eastern slopes ot the Rocky Mountains. The most important of these are the Athabasca and the Peace Rivers; after passing through Athabasca Lake, these unite to form the Slave River, which, on leaving Great Slave Lake, is called the Mackenzie.

The *Coppermine River* traverses the country of the Copper Indians, and passing through several lakes, and over numerous cataracts, it enters the western part of Coronation Gulf, one of the most remarkable inlets of the Arctic Ocean.

Atlantic Coast Rivers.—Most of the streams which flow to the Atlantic Ocean rise in the range of the Alleghany Mountains, which divides the coast region from the basin of the Mississippi. Consequently, none of them have a very lengthened course; but as many of them expand into magnificent bays and harbours, they are of the utmost importance to the commerce and manufactures of the country. The largest of the northern rivers is the Hudson, which has its source in the western valley, on a level with the great lakes; it is navigable to Albany. The Delaware and Susquehanna are important rivers, terminating in spacious bays. The Potómac, which falls into Chesapeake Bay, passes Washington, the capital of the United States, to which the largest ships can ascend; and the James has a navigable channel of 320 miles.

Basins of the Columbia and Western Colorado.—The most important river of North America which contributes its waters to the Pacific Ocean is the *Columbia or Oregon*, which rises in the most rugged steeps of the Rocky Mountains. It forms in its course many rapids and cataracts, presenting great obstacles to navigation; yet vessels of small burden can ascend to Point Vancouver, a distance of about 100 miles, to which point the tide is perceptible.

The *Fraser* has but a limited course, rising in the Rocky Mountains, near the sources of the Columbia; it has a rapid current, and is quite impassable for boats, on account of its numerous cataracts.

The *Colorado* (western) has its sources near the head waters of the Missouri, Columbia, and Del Norte. The Green River, its most northern tributary, rises at the base of Fremont's Peak, latitude 43° 30′ north, longitude 111° west. Its chief affluents from the Rocky Mountains are the Yampa, Grande, Gila, &c.,—the united waters entering the Gulf of California at its northern extremity.

For *Great Salt Lake Basin*, see "Physical Features of America," p. 25.

The *Sacramento* and *San Joachim* water the valley of California between the Sierra Nevada and the coast range of mountains. The former rises near Mount Shaste, and flowing south receives the latter, which has its chief source in the Tulares Lakes. These rivers are remarkable for the quantity of gold found in their streams and creeks.

Basins of the Isthmus of Mexico and Central America.—The countries of New Spain, from their elevated position, possess no navigable rivers of any importance. The narrow form of the continent prevents the accumulation of great masses of water, and the rapid slope of the Cordillera imparts to many of them the character of torrents, which form in their course innumerable falls.

The largest river in the isthmus is the Rio Grande Santiago, called in its upper course the Rio de Lerma. It rises in the table-land of Toluca, and passing through Lake Chapála, it forms numerous falls, and reaches the ocean after a course of about 400 miles. In the table-land of Mexico there are two basins of *continental streams*, which, fed by the periodical rains, part with their surplus waters by evaporation. The small lakes in these basins receive some rivers of considerable size. These streams are used for the irrigation of the country, which, but for them, would be utterly unproductive, since rain falls only in the month of September, and even then it is very uncertain.

In *Central America*, all the rivers flow either to the Pacific Ocean or the Gulf of Mexico. The courses of many of these are still very imperfectly known. The Motagua, which rises in the mountains near Guatemala, and flows into the Gulf of Honduras, offers the longest line of navigation. The San Juan, flowing from Lake Nicaragua to the Caribbean Sea, has acquired importance from the project of uniting the Atlantic and Pacific Oceans by means of a canal, of which it was to form the eastern bed.

SOUTH AMERICA.

As shown by colours on the map, the rivers of South America discharge themselves into the Atlantic and Pacific Oceans, and the Caribbean Sea.

On entering this continent, two small streams, otherwise unimportant, deserve to be noticed, for the purpose of correcting an error which is repeated even in some of the most recent descriptions and maps of this country. These are the Atrato, which, rising in the chain of Choco, flows northwards into the Gulf of Darien; and the San Juan, which runs southwards to the Pacific.

It is said that these two rivers were united by the canal of Raspadura, constructed by the Curé of Novita in 1788, and that in the wet season boats pass on it from the one ocean to the other, thus uniting two points of the coast, separated by a distance of nearly 300 miles; while the fact is, that the canal was never made, the worthy Curé having only pointed out the possibility of its execution.[2]

Basin of the Magdalena.—The *Magdalena* rises in the central Cordillera of New Granada, and, flowing northwards, enters the Caribbean Sea by several mouths. The Bogota, one of its affluents, though of little length, is important, from the fact that it waters the plain in which the capital of New Granada stands, and from the magnificent cascade which it forms in its environs.

Basin of the Orinoco.—The Orinoco is one of the three great rivers of South America, and has many affluents equal to the principal streams of Europe, if we except the Volga, the Danube, and the Dnieper. Of its sources little is known, further than that they rise in the mountain system of Parimé. The most interesting of its affluents is the *Casiquiare*, a branch which it sends off at a right angle to the south-west, and which, after a course of 120 miles, direct distance, joins the Rio Negro, one of the great affluents of the Marañon, and thus connects the basins of the Orinoco and the Amazon. This phenomenon will be more fully noticed under the head *Bifurcation of the Orinoco*.

Basin of the Essequibo.—The Essequibo is the largest of the rivers which enter the Atlantic between the Orinoco and the Marañon. It rises in the Sierra Acaray, which separates it from the basin of the Amazon; and after a course much interrupted by rapids, it discharges itself into the Atlantic by an outlet fourteen miles wide, and separated by three low islands into four different channels. Its principal tributary is the Massaruny. Of the sources of the *Demerara* and the *Berbice*, which flow from south to north, nearly parallel to each other, little is known; these both belong to British Guiana. The extensive inland navigation furnished by the numerous rivers of this fertile region greatly enhances its value as a British colony; and Sir R. Schomburgk[3] shows, that by means of a portage and a short canal, a water conveyance might be opened between Demerara and Buenos Ayres, over an extent of 42 degrees of latitude, while there is ready communication with Lima and the Pacific Ocean, as well as with New Granada, to near Bogota. British Guiana is separated from the Dutch possessions by the *Corentin*. Very little is known of the rivers in Dutch and French Guiana to the eastward of this river.

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[1] See Physical Features of North America—Geological Division, Map No. 7. From this ridge, the elevation of which is estimated at not more than 1680 feet above the level of the sea, descend the three greatest rivers of North America, namely, the Mackenzie to the north, the St Lawrence to the east, and the Mississippi to the south.

[2] The account of this imaginary canal first appeared in A. von Humboldt's *Essai sur la Nouvelle Espagne*, p. 25, in 1811; but the error was corrected by the noble author in a second edition, 1827, and it has since been confirmed by communications from Generals Santander and Mosquera to M. Balbi, *Abrégé de Géog.*, p. 1040, 1844.

[3] Journal Royal Geographical Society, vol. x. p. 267.

Basin of the Marañon.—The Marañon, commonly called the Amazon, is the largest river of the globe, whether as regards the volume of its waters, or the extent of its basin; it is formed by the junction of the *Tunguragua*, or New Marañon, with the *Ucayali* or *Old Marañon*, the former of which, originating in the Lake Lauricacha, is generally stated to be the principal branch, and the source of the Marañon; but we think, with M. Balbi, that the Ucayali, formed by the Apurimac, ought to be regarded as the true Marañon.[1] From its junction with the New Marañon to its confluence with the Rio Negro, the river is called the Solimoes, and it is properly called the Amazon only after its junction with the Negro. This immense river is navigable for large vessels as far as the mouth of the Ucayali, where no bottom is found in the middle of the current at a depth of twenty fathoms; and by its means, a navigable passage exists from the Atlantic to within 300 miles of Lima. After leaving the mountains of Manseriche, this noble stream increases in width from 800 yards to three, and even four miles; and after being joined by the Xingu, it has rather the appearance of a wide arm of the sea than a river. At its entrance into the Atlantic it forms, with the Para or Rio Tocantins, the large island of Marajo. Its inland navigation is estimated at 50,000 miles. The velocity of the stream is pretty uniform, at the rate of 3½ miles an hour; the tide ascends to Obidos, 400 miles from the Atlantic, where the river is still more than a mile wide. Among its affluents it reckons some of the largest rivers in the world.

Basin of the Tocantins.—The River Tocantins is formed by the junction of the Araguay with the Tocantins, the former being the principal branch. It is sometimes, erroneously, described as an affluent of the Amazon, with which it communicates by a natural salt-water canal, called the channel of Tagipuru.

Basin of the Paranahyba.—The Paranahyba, or Parahyba, is one of the five principal rivers of Brazil; it is little interrupted by rapids, and is navigable as far as its junction with the Rio Balas; it enters the sea by five shallow mouths.

The San Francisco, which is another of the chief rivers of Brazil, rises in the Sierra Canastra, province of Minas Geraes, which it traverses from south to north. Its principal affluents are the Velhas and the Verde on the right, and the Paracatu and Rio Grande on the left.

The Rio de la Plata is, properly speaking, only the estuary formed by the junction of the Parana and the Uruguay. The Parana, which rises in Brazil, is the principal branch; it receives on the right the Paraguay, which is increased by the Pilcomayo, the Vermejo, and the Salado—so named from the salt taste of its waters. The estuary of the Plata increases in width as it approaches the sea from twenty-five to upwards of fifty miles, and on meeting the ocean it is 170 miles wide. Its muddy waters can be traced in the Atlantic for more than 200 miles from its mouth.

To the south of the Plata, there are only two rivers which require to be noticed here; these are the *Colorado* and the *Negro*, the courses of which, according to M. Parchappe,[2] are erroneously laid down in all the maps. He says the Rio Colorado, or Mendoza, is formed of two principal branches, one directly from the west, the other from the north; and consequently this river, and not the Rio Negro, must receive the streams which flow from the slopes of the Andes. Notwithstanding the length of its course, the Colorado has but little depth.

The Rio Negro, or *Cusu-Lebu*, is the most important river between the Plata and the Strait of Magalhaen. It forms the boundary between the Pampas and the Plains of Patagonia. Like the Nile, says M. Balbi, it has its source in high mountains, and flows in a valley which it waters by periodical inundations; and, like that river also, it flows over a vast extent of country without receiving any affluent—traversing great arid deserts, which are habitable only in the narrow zone fertilized by its waters. But that which most of all renders this river remarkable, is the fact, as stated by M. Parchappe, that it is the only one which can afford a direct water communication between the Atlantic Ocean and Chile, since it conducts to the famous Col of the Andes, which is never closed with snow, and at which terminated a road opened during the first years of the conquest, which led from Buenos Ayres to Valdivia, and other southern towns of Chile. The traces of this route are now entirely lost, and tradition alone preserves the remembrance of it.

On the right the Negro receives a branch, by which it appears to communicate with an extensive system of lakes and marshes, of which nothing is positively known.

Continental Basin of the Andes Plateau.—There are but few rivers in America which do not directly reach the ocean, and these few, flowing in elevated table-lands, terminate in lakes, the waters of which are lost by evaporation. Some of these, as we have seen, are situated in Mexico, but the most remarkable occurs in Bolivia, where the Rio Desaguadero flows from Lake Titicaca[3] at an elevation of 12,847 feet above the level of the sea, and after a course of 300 miles along the valley of the same name, is lost in lakes and swamps. This plateau contains several other smaller rivers and lakes, of which, however, little is known.

To the south of the continental basin, the country forming the western region of the Pampas is drained by a remarkable system of rivers and lakes. The streams flowing from the eastern declivity of the Andes of Chile appear not to reach the sea,[4] but to discharge themselves into a multitude of lakes communicating with one another by different channels. The best known of these lakes is the Guanacache, the most northern, which communicates with Lake Silverio; and this, again, sends its waters, by the Desaguadero into the Bevedero lakes, and through the latter, by the Salado, into Lake Urre-lauquen. The soil of this region is incrustated with saline matter, and the water of the lakes is said to be salt, although the rivers generally have fresh water.

SKETCH OF THE NIAGARA RIVER.

The River Niagara separates the State of New York from the province of Upper Canada; it is the outlet of Lake Erie, the surplus waters of which it discharges into Lake Ontario, after a northward course of 34 miles. The surface of Lake Erie is 565 feet, and that of Lake Ontario 234 feet, above the level of the sea, so that the whole descent of the river is 331 feet. The boundaries of the lake begin to contract at Black Rock, where the river is about a quarter of a mile broad; after this it gradually widens, till, dividing into two streams, it sweeps round Grand Island, and, when re-united, the river is considerably increased in volume and rapidity.[5] From Lake Erie to the rapids, within little more than half-a-mile from the falls, the descent of the river is only 15 feet, while in the half-mile which intervenes to the head of the falls it is 51 feet. The rapids occupy the whole breadth of the river, from shore to shore. They are formed by the rush of the entire body of water over a rugged bed. Goat Island, about a mile in circumference, divides the falls—the uppermost of which, on the left side, is the Great or Horse-shoe Fall, 153 feet in height, and 1800 feet broad; and lower down on the right is the American Fall, 164 feet in height, and 600 feet in breadth.

Below the falls, the river banks are nearly perpendicular, and from 250 to 300 feet high. At the distance of about half-a-mile below the Horse-shoe Fall, the river has become so little agitated as to admit of the establishment of a regular ferry across the stream, which is here narrowed to less than 1200 feet.[6] Five miles below the falls, a whirlpool is formed by a sudden turn in the river, which checks its course, and forms a dangerous vortex. For about seven miles below the falls the river descends 100 feet, and after passing the Queenstown Heights it enters a plain nearly on a level with Lake Ontario—the whole descent from Queenstown to the Lake being only about four feet. It has long been believed that at one time the Niagara fell over the abrupt bank at Queenstown, nearly seven miles below the present falls, and that it has, during the course of unknown ages, been wearing its way back to its parent lake. On this subject we must refer to the works of Sir C. Lyell,[7] to whom we are indebted for much interesting and accurate information regarding these celebrated falls. "It is an ascertained fact," he says, "that the falls do not remain absolutely stationary at the same point of space, and that they have shifted their position slightly during the last half-century." And he believes that the river supplies an adequate cause for executing the task assigned to it, provided we grant sufficient time for its completion. Assuming the retrograde movement to have been uniform at the rate of one foot per year; 35,000 years would have been required for the retreat of the falls from Queenstown to their present site. Sir C. Lyell adduces evidence to prove the existence of an elevated valley four miles below the falls, and, with great probability, fixes on the position of the "Devil's Hole" as having been at one time the site of the great cataract. He further shows that the falls have diminished in height as they have receded southward, and that this diminution must necessarily continue, until, if ever, they reach Lake Erie.

DELTA OF THE MISSISSIPPI.

The different forms of river deltas, says M. Elie de Beaumont,[8] appear to be only varieties of the same fundamental type. The phenomena which contribute to their formation, and the process even by which human industry affects them, have everywhere the greatest similarity; and the circumstance that these phenomena present a series of phases almost as marked as those of the development of an organised being, greatly augments the interest of their study.

The Gulf of Mexico offers materials for many curious remarks—it may in some respects be compared to the German Ocean, and still more to the Adriatic Sea; since, though vastly larger, a great part of its coast-line completely resembles those which terminate the plains of Lombardy. Like them, they are singularly remarkable for their lagoons, and the delta of the Mississippi recalls, on a grand scale, the delta of the Po.

In the delta of the Mississippi, as in that of the Nile, the Po, &c., the immediate banks of the river are more elevated than the soil at a certain distance from it; hence on both sides there are extensive marshes, which exist throughout the year, so that the greater part of the country, from Natchez to the sea, presents only a vast marshy space—the abode of the alligator, and very insalubrious for man. The shore of the sea is covered with salt lagoons, some of which penetrate far into the land, and form true lakes: these lakes are situated generally between the lagoons, and sometimes communicate with, and even traverse them. These lagoons are very shallow, varying from 5 to 19 feet below the general level of the delta.

The delta of the Mississippi commences at the point where the *Atchafalaya* (probably the original bed of the Rouge, or Red River) branches off towards the west; from this point to Balize, at the mouth of the south-east passage, it measures nearly 200 miles—an extent equal to that of the Ganges. The breadth of its base is very considerable, and it forms altogether a triangle somewhat larger than that of the delta of the Nile, the proportions being as four to three nearly. A great part of this triangle, and of the low land adjacent, is constantly covered with water. During the inundation, as shown on the map, nothing remains above this vast temporary lake but a narrow belt along the greater part of the river-course; while in summer the surface of the river is depressed about 40 feet at the head of the delta, and 20 feet near New Orleans.[9] The numerous branches of the river, which bear the generic name of *bayous*, differ in many respects from the river itself; they are of comparatively little depth, and, except during the inundation, they carry to the sea only a very small portion of the Mississippi; it often happens, indeed, during summer, that instead of taking water from the river, some of them convey to it the waters they have collected from the marshes of the plain.

The largest of these bayous is the *Atchafalaya*, which discharges a part of its waters into the gulf of the same name, and returns a part to the original trunk, with which all the other branches of the delta are more or less connected. The others are, on the right, the *Plaquemine* and the *Fourche*; and on the left, the *Iberville*, the *Gentilly*, and the *Bienvenu*.

Comparing this delta with that of the Nile, M. de Beaumont remarks, that the principal stream of the Mississippi represents, in the Nile Delta, the Rosetta branch. The Iberville, which traverses Lakes Maurepas and Pontchartrain, represents the Canopic branch of the Nile, now obliterated, the ancient bed of which separated Lake Madich from Lake Etko. The Fourche represents the Damietta branch of the Nile, and the Atchafalaya the ancient Pelusiac branch. But no one branch of the Nile bears such a proportion to any of the others as the principal stream of the Mississippi does to the bayous which are derived from it. The *Anse aux huitres*, and the other lagoons which extend from it towards Texas, may be compared to those between Pelusium and El-Arish. Lake Menzaleh is only imperfectly figured by the Lake of *Chetimaches*; but the *Port of Barataria* represents Lake Bourlos of the Nile delta, and the *étang de Valcares* that of the delta of the Rhone. Finally, the Atchafalaya is to the Mississippi nearly what the Adige is to the Po.

Along the banks of the Mississippi, as on those of the Rhine, the Rhone, and the Po, dykes, here called *levées*, are constructed, to preserve certain lands from inundation; and these are continued also along the canals and bayous, in which water flows only during the rainy season. The space near Natchez thus reclaimed, by means of dykes erected by the French when they colonised Louisiana, is covered by plantations of cotton and sugar-canes.

Pursuing its course directly to the Gulf of Mexico, the Mississippi advances beyond the line of the continent, in a channel which it has formed for itself by the accumulation of mud and drift-wood; and which it gradually extends towards the lower part. For a considerable space above its mouth, the banks present nothing but marshes covered with reeds, and containing only some fishermen's huts. The principal stream of the Mississippi discharges itself into the sea by several mouths, among which five are remarked, all differing greatly in the number and size of the islands which are formed in them, and by the depth of the channel above their respective bars. The five principal mouths of the river, diverging from a central point, are thus placed at the extremity of as many arms, extending from four to six miles in length. The most important of these is the south-east passage, where the pilots have erected a wooden tower, called Balize. The water on the bars at the mouths of each of these passes is comparatively of little depth, being in the grand pass from 13 to 16 feet, in the south-west passage only 10 feet, and in the others still less. The shallowness of the water on these bars is very remarkable, when we compare it with the depth of the Mississippi, which averages from 98 to 130 feet. This furnishes a striking example of the powerful action of the sea, in rejecting matters carried to it by the river.

During the inundation, in spring, the lower part of the Mississippi is no longer a river—it becomes a kind of muddy sea (spreading many miles on the right and left of its trace, and covering an area of nearly 40,000 square miles) which precipitates itself towards the Gulf of Mexico, bearing with it an immense quantity of wood torn from the borders of the river and its affluents. These trees, mixed with the mud of the river, form the soil of the delta, and daily prolong the promontory which bears to the ocean the waters of the Mississippi. M. de Beaumont calculates the mean annual amount of this prolongation at 1150 feet, showing a rapidity of extension five times greater than that of the delta of the Po. But he shows, at the same time, that this amazing increase is a temporary, and, so to speak, an artificial phenomenon, produced partly by the dykes by which the river is enclosed, and partly by the system of cultivation of which North America is at present the theatre—that there is no evidence of the solidity of the structure, there being probably nothing permanent either in the extension or its effects; and that the narrow and shifting canal which it has formed affords no solid basis for speculations on the rapid conversion of land in the sea, on which a system has been attempted to be erected. This shifting delta-land gives rise to strange phenomena; and Major Delafield has collected many facts which prove that at certain times there is manifested a prodigious elevatory force in the vicinity of the bar—an upheaval which is doubtless accompanied by a depression elsewhere. Thus, a schooner, having been wrecked, disappeared under water, the top of the mast alone being visible; some time afterwards the vessel was found cast out of the water upon an island. Again, an English ship, which carried slabs of Portland stone, as ballast, to New Orleans, on arriving at the bar, was obliged to cast part of her cargo into the sea, and in a short time afterwards the slabs were likewise found thrown upon an island. M. de Beaumont further shows that there is no ground for the fear that these combined causes will ever succeed in filling up the Gulf of Mexico, for the whole extent of the territory which these rivers drain would scarcely suffice to fill its basin; and there is no probability that these countries are to be demolished to their base, and carried off by the waters which flow on their surface, even in the most distant futurity.

BIFURCATION OF THE ORINOCO.

America possesses many of those natural canals, the definition of which is sought for in vain in geographical treatises. The largest known of these is the *Casiquiare*, which forms the *bifurcation of the Orinoco*; and the union thus formed between the Orinoco and the Amazon is among the most remarkable phenomena of physical geography. The Orinoco is one of those singular rivers which, after having made many detours to the west and the east, follows at last such a retrograde direction, that its mouth is found almost in the same meridian as its source. From the river Ghettè to the Guaviarè, the Orinoco flows to the west, as if it would carry its waters to the Pacific Ocean. Within this space it sends off to the south the remarkable branch called the Casiquiare, which unites it to the Rio Negro, or, as it is called by the natives, the Guainia: forming a unique example of the junction of two great rivers. The fact of the existence of this natural canal was announced by the Portuguese more than half a century ago; but systematic geographers combined in an attempt to prove that such a communication of rivers was impossible; and among others who denied its existence we find Gumilla,[10] author of the "Orinoco Illustrado" (1742), who resided three years in the missions in its vicinity; and M. Buache,[11] in his map of Guiana, in 1789. After having long been a subject of doubt, Baron Humboldt set the question at rest by traversing this singular net-work of waters in the year 1800, and it has been more recently explored by Sir R. Schomburgk.[12] An uninterrupted navigation of 381 leagues, says Baron Humboldt, conducted me from the Rio Negro, by the Casiquiare, into the Orinoco, or from the frontiers of Brazil, by the interior of the continent, to the coast of Caracas. And further: "Since the year 1767, two or three canoes come annually from the fort of San Carlos, by the bifurcation of the Orinoco to Angostura, to fetch salt and pay the troops. These voyages from one basin of a river to another, by the natural canal of the Casiquiare, excite no more attention in the colonists at present, than the arrival of boats, that descend the Loire by the canal of Orleans, awakens on the banks of the Seine." The accompanying map is from the survey of A. von Humboldt, whose description of this singular phenomenon is so complete, that, as Sir R. Schomburgk remarks, little is left for any subsequent traveller to add. The length of the Casiquiare, according to the last-named eminent observer, is 120 miles direct distance, or 176 including its windings; and where it strikes off from the Orinoco, its width is 100 yards: it widens considerably on approaching its junction with the Guainia, and at its mouth it is about 550 yards—the Guiana being about 600. The latitude of the junction is 1° 59′ north. It is believed that many similar communications exist, especially during the rainy season, between the different river-courses of this region. Among these the supposed course of the Itinivini, uniting the Rio Negro with the Casiquiare, is traced on the map.

HYDROGRAPHIC TABLE OF THE NEW WORLD.[13]

NAMES OF RIVERS.	Extent of River Basins.	Direct Distance of Rivers from Source to Mouth.	Extent of Development of Streams.	Extent of Windings of Streams.	Proportion of Windings to Direct Distance.
	Geog. Sq. Miles.	Geographical Miles.			
ATLANTIC SYSTEM.					
Great Lakes and St Lawrence,	297,600	860	1,800	940	2.1
Connecticut,	8,000	231	270	39	0.2
Delaware,	8,700	180	265	85	0.5
Orinoco,	252,000	368?	1,352?	984	2.6
Essequibo,	61,650	350	420	70	0.2
Maranon,	1,512,000	1,548	3,080	1,562	1.0
Tocantins,	284,480	990	1,120	130	0.1
Paranahyba,	115,200	560	744	184	0.3
S. Francisco,	187,200	872	1,400	528	0.6
La Plata,	886,400	1,028	1,920	892	0.9
SYSTEM OF THE GULF OF MEXICO AND CARIBBEAN SEA (AMERICAN MEDITERRANEAN).					
Mississippi-Missouri,	982,400	1,412	3,560	2,148	1.5
Rio del Norte,	180,000	1,220?	1,840?	620	0.5
Motagua,	7,040	196	260	64	0.3
Magdalena,	72,000	560	828	268	0.5
ARCTIC SYSTEM.					
Mackenzie,	441,600	964	2,120	1,156	1.2
Churchill,	73,600	668?	848?	180	0.3
Saskatchevan,	360,000	924	1,664	740	0.8
Albany,	52,800	380	560	180	0.5
PACIFIC SYSTEM.					
Columbia,	194,400	576	1,360	784	1.4
Colorado,	170,000	512	800?	288	0.6

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[1] Balbi, *Abrégé de Geog.*, p. 296. This learned geographer is wrong, however, in supposing that the Beni joins the Apurimac.

[2] Quoted by M. Balbi, *Abrégé de Géographie*, p. 1068.

[3] The lakes in the southern present a remarkable contrast with those in the northern part of the continent. Titicaca is the largest lake in South America, and, notwithstanding its vast extent, the surface of its waters is more elevated than the Peak of Teneriffe.

[4] M. Parchappe, however, seems to think that these rivers communicate with the Rio Colorado.

[5] At this distance, about three miles from the falls, the noise of the cataract is distinctly heard, and a cloud of mist points out its locality. In favourable circumstances, the roar of the water is sometimes heard at a distance of 40 miles.

[6] Two miles below the falls a suspension bridge, 800 feet in length, connects the Canadian and United States railways.

[7] See the whole subject of the retrograde movement of the falls, ably discussed in "Travels in North America," vol. i., p. 27, &c.

[8] Leçons de Géologie Pratique, tome i., p. 504.—1845.

[9] The Mississippi and Ohio Rivers, with Plans for the Protection of the Delta from Inundation. By CHARLES ELLET, junior, C.E. 1853.

[10] Journal du Voyage a l'Equateur, par M. de la Condamine, p. 193.

[11] In a note appended to this Map he says:—"The long-supposed communication between the Orinoco and the Amazon is a monstrous error in geography."

[12] Jour. Royal Geog. Society, vol. x., p. 248.

[13] By D. H. Berghaus, chiefly from calculations by DENZEL, communicated in MS.

PLATE 18

DISTRIBUTION OF HEAT OVER THE GLOBE.

ISOTHERMAL LINES, OR LINES OF EQUAL TEMPERATURE.

THE endeavour to become acquainted with the complicated distribution of temperature on the surface of the earth has led to a series of laborious investigations and experiments. Lambert, in his *Pyrometrie*, 1779, first treated of the radiation outwards, or from the earth, Halley having only considered the radiation from the sun to the earth. Fourier and Poisson, in their subsequent Theories of Heat, included the influence of the earth's own temperature among the sources of heat; the influence of this cause in lessening extremes of variation was pointed out by Mairan, in the *Mém. de Paris*, 1719, 1765. The Romans first became acquainted with the peculiarities of a sea or insular climate by the conquest of Britain, of which Cæsar remarks that its climate is more temperate than that of Gaul, and Strabo says that "Britain is rendered inhospitable by rain rather than by snow." When Europeans first settled on the Atlantic shores of America, they found the temperature so much lower than in corresponding latitudes in Europe, that the Hudson River, on the same parallel as Rome, was frozen over for 87 days in the year, and they inferred that this comparatively low temperature extended across the Continent. The New World thus believed to be so much colder than the Old, led Halley to suppose that the earth had once rotated round an axis the direction of which had been from North America to a point in the sea south of the Cape of Good Hope. The assumption that America was everywhere much colder than Europe under the same parallels, was first controverted by George Forster in 1794, who showed that the interior valley of North America, west of the Alleghanies, has a much milder climate than the east coast in the same latitude, and that this difference is observed to extend to the Pacific coasts west of the Rocky Mountains. Cotte, in his *Mémoires sur la Météorologie*, 1788, gave the first extensive collection of actual observations, and Kirwan (*Irish Trans.* vol. viii.), made the first general investigation on the distribution of heat, founded on observation. He constructed a table of monthly temperatures for all parallels of latitude between 10° and 80°: he remarked that the temperature of the month of April approximates to the mean of the year; that July is the warmest month in latitudes above 48°, and August in lower latitudes. Humboldt, in 1817, published his celebrated treatise, "Des lignes isothermes et de la distribution de la chaleur sur le globe" (*Mém. de la Soc. d'Arcueil*, tom. iii.), in which he described the method of obtaining the mean annual temperature of a place by the elimination of the periodical variations. He determined the mean annual temperature of the equator, and showed that the decrease of heat with the increase of latitude takes place more slowly on the west coasts of the Old, than on those of the New World. He next connected places having an equal amount of heat on the average of the year, by isotherm lines, and showed that the convex summits of such lines fall near the west coast of the Old, and their concave summits on the east coast of the New World. Combining the decrease of temperature by increasing elevation, with its decrease by increasing latitude, he represented the intersections of the isothermal surfaces with a vertical plane cutting the surface of the earth along a meridian; and showed that, if the examination of places of equal summer heat and equal winter cold, were conducted in a similar manner, by drawing isotheral and isocheimal lines, the difference between a sea and a continental climate would be included in the general view. The little map which accompanies his memoir shows only the isothermals of the year; and Kämtz and Mahlmann, in their discussions of the more extended materials since furnished by observation, have represented only the annual isothermals. The method of comparing monthly temperatures was first adopted by Professor H. W. Dove, and published in the *Transactions of the Royal Academy of Sciences*, Berlin, in 1846. These were reprinted in degrees of Fahrenheit's scale in the *Transactions of the British Association*, in 1847. His three first maps of the monthly isothermals of the globe were published in 1849; and the entire work, which was completed in 1852, was translated by Mrs Sabine, and presented to the British Association in 1853.[1]

ON THE CAUSES OF PERIODICAL CHANGES OF TEMPERATURE.

The earth, in common with all bodies, whatever be their temperature, parts with heat by radiation in every direction. It would thus be subject to an uninterrupted process of cooling, if the temperature which it loses in this way were not replaced by heat received by radiation from other bodies. No trace has yet been discovered of warmth received from the planets or fixed stars, and only recently a slight indication of such has been obtained in the case of the moon. The sun, therefore, is the only external source whence the earth can be regarded as deriving its heat.[2] Since the earth rotates with a constant velocity round an axis having always the same inclination in its revolution round the sun, every part of the earth's surface must be exposed to the sun's rays during one-half the period of its revolution, and be in shadow during the other half. Thus, while each part loses heat by radiation during the whole year, it receives it from the sun during only half that period; and if the heat received from all sources, external and internal, were exactly equivalent to that which it loses by radiation, it would preserve its mean temperature unaltered. But although every part of the earth's surface receives the same aggregate amount of heat from the sun, yet the annual distribution of that amount differs exceedingly. Around the pole it forms one continuous day of six months, succeeded by a night of equal duration; while every place on the equator is alternately exposed to, and withdrawn from, the sun's rays for twelve hours uniformly throughout the year; and between the two extremes there exists every intermediate stage of transition. The movement of the earth round the sun causes an apparent circuit of the sun in the heavens in the course of a year, and from its rotation round its own axis apparent circuits of the sun round the earth are produced every twenty-four hours. These latter circuits are inclined to the first, as the earth's axis of rotation is inclined to its orbit. As regards the time of the reception of the sun's rays, two periods are distinguished—the one *diurnal*, which is the only one experienced at the equator; and the other *annual*, which is the only one at the poles. These two periods pass into each other through all the intermediate parallels of latitude. The higher the sun rises above the horizon, the more of his rays impinge on a given surface; thus the radiation received increases up to apparent noon, and then decreases in a similar manner. The minimum temperature is at sunrise; but the maximum temperature does not occur until after the time of the sun's greatest altitude. At all parts of the earth, except at the equator, the time during which the sun's rays are received in the course of the diurnal period, increases for one half of the year, and decreases for the other half; and besides this, for all places in the temperate and frigid zones, the sun's meridian altitude increases always with the length of the day: hence there is for all such places the concurrence of two causes acting in the same sense to produce an annual periodic variation of temperature, having one maximum and one minimum. Within the tropics the sun's greatest altitude does not coincide with the longest day; for the sun passes through the zenith twice in the year, while there is only one longest day. At the equator itself the length of the day is the same throughout the year, and the two epochs of the sun's greatest altitude are half a year apart. Here, therefore, the temperature follows a semi-annual period; and in advancing from the tropics to the equator, the temperature curves become gradually transformed from a simple curve with one convex summit into a curve having two equidistant maxima. As regards the annual period, the difference between the highest and lowest temperatures in the year increases in advancing from the equator toward the poles. Within the tropics the difference of the sun's meridian altitude, at different periods of the year, is less than beyond them; and, in advancing thence towards the poles, the difference of time during which the sun's rays are received in the periods of the year becomes constantly greater. Hence it is evident that the mean temperature of the year will decrease with increasing latitude, since the time for which the sun's rays are received being equal, the intensity of the imparted heat will increase with the varying increase of the sun's meridian altitude. Both diurnal and annual differences diminish rapidly with increasing depth, and even become insensible at 100 feet below the surface; hence the cause of the variations of temperature at the earth's surface must be sought for in external sources only. But the increase of heat not subject to periodical variation with increasing depths below the variable stratum, shows that the mean value of the temperature at the surface of the earth is determined by conduction from within, as well as by radiation from without. The internal heat of the globe must therefore be considered as constant in its effects, lessening the extremes, but not affecting the periods of the variations of temperature at the surface. Practically, the surfaces of the ocean and of the dry land may be regarded as the floor or base of the atmosphere; and if the sun's rays passed through it without raising its temperature, the atmosphere would then be held as being heated exclusively by the sun-warmed surface of the earth. This, from its great, though imperfect transparency to heat, is very much the case. The temperature of the atmosphere, apart from the influence of aqueous vapour, is therefore raised in four ways: 1. By the direct rays of the sun; 2. By the reverberation of those rays from the earth's surface; 3. By contact with the ground; and 4. By contact with the ocean under its different temperatures. The quantity of heat required to warm a given volume of denser air is less than is required to raise the same volume of rarer air to the same temperature. As the sun's altitude is lessened, the effect of his rays upon the ground will be diminished from the smaller number of rays impinging on a given surface, and from the decrease in their intensity, owing to their path being prolonged through the atmosphere, which, not being perfectly transparent to heat, absorbs a portion of them. The elasticity of the air, heated by contact with the ground, meets an equal resistance in all horizontal directions; but in the vertical direction the resistance is less above than below. Hence it ascends, and is cooled by increasing rarefaction, since the heat which it abstracted from the ground in its denser state cannot maintain it at the same temperature when rarefied. Therefore temperature decreases with increasing elevation. But the cooling effect of radiation is lessened in consequence of the aqueous vapour which ascends along with the warm air. An enormous amount of heat is absorbed at the base of the atmosphere during the process of the thawing of ice and the evaporation of water, but when the vapour is reconverted to water, the heat so absorbed is again given out. The formation of clouds takes place chiefly in the higher parts of the atmosphere. These, at a definite height, intercept the sun's rays, and then the heat, which in clear weather is generated in by far the greatest amount at the bottom of the atmosphere, is retained in its upper strata, although warm showers falling from a thick mass of clouds, which have been so warmed, may restore to the lower shaded strata a portion of the heat of which they have been deprived. The reverberation of heat from the ground depends on the nature of the surface, and this kind of radiation acts more powerfully in causing the melting of snow than the direct rays of the sun, and it is thus that in winter every bush and post lessen the depth of snow around them. The air is warmed in a very different degree as it comes in contact with a solid or a liquid base. A liquid surface is constantly renewed, because every depression of temperature causes the water at the surface, which by cooling has become denser and heavier, to sink down and make way for the warmer water which rises from below to replace it; and this goes on till the density of the fluid mass is the same throughout its entire depth. Besides this, the sea is less heated by direct radiation than the land, because the process of evaporation, or the conversion of part of the water into vapour, employs heat, which, if the surface were land, would be given directly by contact to the adjacent air. In lateral directions the exchange of temperature takes place, in solid strata, by the medium of conduction, and in liquid and gaseous or aerial strata, by movement of the particles. Thus winds and currents lessen the differences of temperature produced by latitude, in the same manner that ascending and descending masses of air lessen the differences of temperature in the higher and lower regions of the atmosphere.

THE MONTHLY ISOTHERMALS.

In order to avoid the introduction of new names analogous to "isotherals," "isocheimals" for the different months, Professor Dove uses the term "yearly isothermals" for those lines of annual mean temperature called simply "isothermals," and understands by the term "monthly isothermals" curves connecting places having equal temperatures in the same month. He gives a separate map for each month in the year on the equatorial projection; a separate map of the isothermals of January and July combined, on the equatorial and polar projections; a series of the thermic isabnormals for each month; maps of the annual isothermals and thermic isabnormals on the equatorial projection; and those from January to July on the polar projection. Of these we have selected, as most interesting and instructive, the isothermal lines of mean annual temperature, the lines of isabnormal mean annual temperature, and the isothermals of January and July on the equatorial projection; and on the polar projection, the isothermal lines of mean annual temperature for the northern and southern hemispheres, and the lines of isabnormal temperature for January and July. In these the portions of the globe in which the temperature is above the freezing-point are coloured Pink, and those below freezing Blue. Detached portions of highest temperature, in the isothermal maps of January and July, are shaded in Red—the district, including Nubia and part of Arabia, temperature + 90°, being the warmest in July, and the oblong shaded space in Siberia, temperature — 40°, the coldest in January. The temperature of the air decreases either in receding from the equator towards the poles, on the same level, or in ascending higher in the atmosphere in the same geographical locality. Hence we may arrive at points having the same mean temperature by an infinite number of directions. All these directions fall into a plane, which, like the snow limit, rises higher and higher in advancing from the poles to the equator. Such an isothermal plane cuts the surface of the earth as an isothermal line; and, since the irregular elevations of the earth's surface would complicate the forms of these intersecting lines, it is found more convenient to prolong the planes to the level of the sea; that is, to add to the temperatures observed at the several stations, such values as will be equivalent, in each case, to the decrease of temperature due to their elevation above that level. As the decrease of temperature for an elevation exceeding 300 feet only amounts to one degree of Fahr., this correction for elevation is inconsiderable for places situated in ordinary low lands. All the isothermals in the maps correspond with, or are reduced to, the level of the sea. Since the isothermal planes rise or fall with the increase or decrease of the sun's meridian altitude, so the isothermal lines travel periodically to and fro on the surface of the earth. As the sun's meridian altitude increases in the northern hemisphere at the same time that it decreases in the southern, and *vice versâ*, so the isothermal planes are rising in the northern, when they are sinking in the southern hemisphere; and the northern isothermal lines are moving towards the pole, while the southern ones follow them by moving towards the equator. The movement is always in the same direction in the two hemispheres; *i. e.* from south to north from our winter to our summer solstice, and from north to south in the other half of the year. But as the rate of progress is very different at different points, the several isothermals are continually changing their forms. The distribution of temperature is not therefore merely removed bodily to and fro on the earth's surface within the annual period, but it also becomes, at different seasons, quite altered in its character. Within the tropics the sun's meridian altitude changes less than beyond them; hence the annual changes of temperature are less than in the temperate and frigid zones, and the rising and sinking of the isothermal planes is inconsiderable near the equator. Prof. Dove gives, as an example of the isothermal planes, the one which passes through the chalet of Antisana, near the equator, at an elevation of 12,624 feet, and touches the general surface of the earth, in the month of January, a little north of Montpelier and Bordeaux, in May at Torneo and Archangel, intercepting, in passing, the summit of the Brocken, and in July descending to the sea-level only near the middle of Spitzbergen, leaving in that month the summit of the Faulhorn below it. He classes the different isothermals into, 1. Those which are always found in pairs, intersecting both hemispheres, including all between 32° and 77° Fahr.; 2. Those which are sometimes single and sometimes in pairs, sometimes intersecting one or other hemisphere only, and sometimes both. To this class belong many of the isothermals below the freezing-point; and some of those of highest temperature, which do not pass through all meridians, for example, 81° Fahr; 3. Those which always occur singly, or in one hemisphere only, at a particular season, not touching it in other parts of the year. To this class belong those of lowest and those of highest temperature (— 40° in January, Siberia, and + 90° in July, Africa), which are only developed at particular seasons, and inclose detached spaces; and, 4. The isolated patches of highest temperature, which are developed at particular places in the torrid zone, without passing through all meridians, and are enclosed by isothermals that *fork*, *i. e.* divide into two branches (79° and 81° Fahr.)

The temperature of any particular month varies very much in different years. Its true value can, therefore, only be concluded from observations during a long series of years; and these exist for so few places, that, if limited exclusively to them, the points through which the isothermals are drawn would be too few in number. It was, therefore, necessary to find some means of connecting observations which extend over only a few years, so that they might be in some degree equivalent to conclusions drawn from a longer period. In his inquiries[3] Prof. Dove found "that important variations are never merely local, but that the same character of weather prevails over large portions of the globe; that the anomaly reaches its maximum in one spot, in receding from which it lessens more and more, until, passing through places where the thermic conditions are in their normal state, an opposite extreme is reached, which so compensates the first, that the general sum of warmth distributed over the earth at any particular time of year, is the same in different years, although the values which make up the sum may be very different. Knowing the prevailing character of the weather in particular places, in the different years, we are enabled to deduce, from the directions of a few normal stations, where the observations extend over a long series of years, the quantitative correction to be applied to the results of observations continued for only a few years."

In *January* (see Map) the isothermals fall, in the New World, in the middle of the continent; in the Old World also, in the interior, but much nearer the east than the west coasts: the convex summits fall in the intervening oceans. The curves rise steeply from Labrador towards Spitzbergen, thence they sink perpendicularly to Norway, their eastern sides forming overhanging loops towards Novaia Zemlia. Here the effect of the Gulf Stream is very apparent. The line of 32° Fahr., which sinks in crossing from the Pacific to the Atlantic Ocean, passes from Philadelphia across the banks of Newfoundland, through the south of Iceland, beyond the arctic circle, which it crosses in the meridian of Brussels. Thence it descends in the direction of the meridian south, through the west coast of Norway to the Netherlands. Its course is then south-east towards the Balkan Mountains, in Turkey. Proceeding in a south-east and east direction, it crosses the middle of the Black Sea, and the south of the Caspian, across Asia, to the peninsula of Corea, whence it rises to the Aleutian Islands, and falls in the direction of the Rocky Mountains, to Fort George, on the Pacific. Thus in passing in January from the Shetlands, down the east coast of Great Britain to the Channel, the temperature is not altered, whilst it increases rapidly in proceeding to the westward, since the extreme point of Cornwall, and the west coast of Ireland, are both beyond the line of 41° Fahr. The circumstances are still more marked in Scandinavia. From the intervention of the British Islands, the south parts of Norway are less open to the warm waters of the Gulf Stream than the north parts; hence in January the temperature actually increases in proceeding from south to north, and at the North Cape the south-east winds are the coldest. The Scandinavian Alps and the Rocky Mountains form dividing walls in regard to climate. In approaching the tropics, the curves flatten, so that the isothermal of 68° nearly coincides throughout with the tropic of Cancer, having only slight concavities in Africa and the eastern peninsula. The dividing isothermal between the north and south thermal hemispheres, 79° Fahr., is a simple line near the Galapagos, but on the east and west it branches out so as to enclose a connected space of highest temperature, narrow in the Atlantic, but expanding in South America, the Indian Ocean, and Polynesia. Beyond this space temperatures above 81° Fahr. are only exceptional, and do not form a continuous line. The fact that the space of highest temperature is farthest south in the Indian Ocean, which is also the locality of highest absolute temperature, is the reason why the north-east trade-wind becomes at this season a north-west monsoon (see Distribution of Winds and Storms, Plate 19, p. 61). The greatest difference of mean temperature comprised between 70° north and 70° south latitude in January, is 121° Fahr. The thermic equator falls everywhere, except in Colombia and Guinea, in the southern hemisphere. The isothermals of the southern hemisphere are much more inflected in the torrid than in the temperate zone; where the alternation of land and sea from east to west ceases, the causes of inflection are absent. Besides the different effect of radiation on a solid or a liquid base, the configuration of continents is influential in determining the courses of marine currents. The isothermal lines across the ocean are drawn exclusively from the observations of atmospheric temperature, the temperature of the sea never being taken into account. The great curvature of the isothermals in the South Atlantic is shown by comparing the temperatures of Rio Janeiro, St Helena, Ascension, Christiansborg, Cape Town, and the Isle of Bourbon: St Helena being much colder than the lower islands. The isothermal of 32° in the southern hemisphere, is only determined approximatively for December, January, February, and March. It is comparatively but little inflected. The drift-ice of the antarctic regions being everywhere exposed to the uninterrupted action of an open ocean, although it may consist of more compact masses, can never form into such extensive fields as the ice of the northern seas; and from its state of disruption is far more variable in its place in different years. A comparison of different voyages leads to the conviction that, before reaching the barrier of fixed ice, the temperature dependent on the position of the movable ice may vary considerably from one year to another. In *February* the isothermals in Northern Asia begin to move towards the north, while in North America their movements are still southwards. They become more steep in Baffin and Hudson bays, and begin to flatten in Siberia. The temperature of 81½° is observed in two separate spaces, one in the interior of South America, the other in Central Africa, the larger portion being in the southern hemisphere. In *March* the spaces in America and Africa, enclosed by the isothermal of 81½°, have united. The Asiatic curves are more than ever flattened. In the Kirghis steppe the depression of temperature continues to be remarkable, and does not disappear till *April*, when two spaces of very high temperature, bounded by isothermals of 86°, are formed in the middle of Northern Africa and the interior of Western India. Throughout Asia and middle Europe the isothermal lines are nearly parallel with the lines of latitude. Only the curves of 41°, 32°, and 23° pursue their remarkable bend. The line of 23° Fahr. passes from the south of Hudson Bay along the west coast of Greenland up to Spitzbergen, and descends thence to the entrance of the White Sea. The line of 32° runs from Cape Breton to the south point of Greenland, through Iceland, nearly to Bear Island, and thence to the North Cape. From this point it descends on the crest of the Scandinavian Alps to the parallel of Trondheim, where it bends to the east. This phenomenon is caused by the ice drifting down from the coast of Greenland and Baffin Bay; and the effect of this is still more marked in *May*, when, from Nova Scotia to Newfoundland, the isothermals are crowded closely together: hence in the spring at Newfoundland the remarkable appearance of the "silver dew," when the warm south winds cover the trees with a thick crust of ice; and hence also the thick fogs which are met with at this season at the entrance to Baffin Bay. The hot space in Africa, bounded by an isothermal of 86°, has now extended and united with the hot space in Western India. Towards this space the south-east trade-wind advances in the form of a south-west monsoon. In *June* the hot African space reacts in Europe north to Christiania; the isothermals continue to rise near the west coasts of Europe, and do not begin their easterly curve till they arrive in the meridian of Berlin. The cold water from the Icy Sea through Fox Channel, Behring and Waigatz straits, produces concave inflections in the usually regular curve of the isothermal lines at this season. In America the lowest parts of the lines are close to the east coast: the warm space enclosed by a line of 81½°, which in May had been formed in the Caribbean Sea, now embraces the whole of that sea and the Gulf of Mexico. The curves in the southern hemisphere are extremely flattened, the difference between the east and west sides of South America is less sensible, and the cooling effect produced by the melting of drift-ice is greatly diminished. In *July* (see Map) the extreme temperatures are manifested within the elongated space enclosed by the isothermal of 86° in Africa and Asia; another space enclosed by an isothermal of 90° has been formed, including Nubia and the south of Arabia, countries in which "the earth is fire and the wind flame." The temperature since May has also become extremely high in Western India; hence the south-east trade-wind, in the form of a south-west monsoon, follows up the retreating north-east trade to the foot of the Himalayas; and on the extensive continent of Asia high temperatures advance so far to the north, that, over ground perpetually frozen at the depth of a few feet, the limit of arboreal vegetation advances to the parallel of latitude 72° north (see Plate 25). In Europe and Asia the isothermals become convex in the interior of the continent. The thermic normal, enclosing a space warmer than the normal condition, includes all Asia, Europe, and Africa north of the equator: the portion that belongs to the proper sea climate includes Scotland and Ireland, Labrador, Canada, the region to the north-west of Hudson Bay, and the margin of coast from California to mid-way between Icy Cape and the Mackenzie River. In the warm space of the Mexican Gulf there are no traces of temperature so high as those of Africa and Hindostan, Maracaybo reaching only 86° Fahr. The thermal limit between the northern and southern hemispheres has only advanced a little toward the north in this part of the globe since the beginning of the year, but on the eastern side it touches the northern tropic in several places. In North America the isothermals have moved laterally, their concavities having advanced from the interior to the east coast, until in Europe and Asia the concave form has been changed into a convex one; their July course, in the greater part of North America, in Europe, and in Asia, being perpendicular to the direction which they follow in January. In the southern hemisphere the isothermals from 59° to 34° Fahr. are thickly crowded, and very flat. In *August* the isothermal curves assume two characteristic convexities, one at Spitzbergen, and the other beyond the mouth of the Lena. On the coast of Greenland the cold in the high north begins to increase; there is less drifting ice to the southward, and the coasts of North America are permitted to retain more of the heat they receive, and the curves become flatter. This is the case to a still greater degree in *September;* and as the cold from New Siberia now begins to invade the continent of Asia, the convex summits are similarly flattened. This, therefore, is the season when the distribution of temperature over the globe is most regular, even America forming no exception. From the same causes this is the month which shows the fewest anomalies in single years; for when the temperature is equally distributed in the east and west direction, easterly and westerly winds or currents of air cease to exert any disturbing thermal effect. Within the tropics the temperature begins to sink, showing clearly that, as the sun passes from the northern to the southern signs, a larger portion of the heat dispersed by his rays becomes latent. The West India Islands are withdrawn from the space enclosed by the isothermal of 81½° Fahr., which has now contracted to a narrow strip of coast from Vera Cruz to Cayenne; the space included by the same isothermal in Africa has retreated from the west coast to the interior; and the space enclosed by the isothermal of 86° Fahr. now only includes Kordofan, Nubia, and Arabia, no longer extending to Hindostan. In *October* this space begins to disappear. The cold now comes in decidedly from the north; at the mouth of the Lena, in Siberia, the isothermal of —17½° Fahr. already reaches the continent of Asia, and the temperature of Melville Island has sunk to —4°.8 Fahr. The cold approaches the old continent from the north-east, and the new continent from the north-west. In *November* the isothermals in both continents become decidedly concave; while the hottest space in the tropics now falls in the Indian Archipelago. The curves in the southern hemisphere become increasingly inflected as the increasing altitude of the sun renders the difference between land and sea more marked. In Europe these extraordinary involutions have already begun, which in *December* are still more decidedly formed, and which cause the isothermal of 41° Fahr. to run from the Faroe Islands to the western side of France, in the latitude of Rochelle, passing along the west coast of Great Britain. The curves of December indicate a near approach to the extreme forms of January.

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[1] From the data furnished by these treatises, to which the reader is referred for details, the four horizontal and three north polar projections have been constructed. In the south polar projection, the space coloured blue is only to be considered as approximatively correct, there being no observations sufficient to warrant a definite boundary for the southern hemisphere.

[2] Nervander and Buys Ballot have suggested that, if the emission of heat be unequal at different parts of the surface of the sun, the phenomena of temperature may be expected to present a period corresponding to that of the rotation of the sun round its axis.

[3] These investigations embraced the thermic march of the weather during an interval of 115 years, 1729 to 1843 inclusive, and were published in the *Transactions of the Berlin Academy* for the years 1838, 1839, 1842, and 1845.

Mean Decrease of Temperature from the Equatorial to the Polar Regions.—Dove shows that in every month of the year the decrease of temperature from the equator to the poles is very different under different meridians. In determining this decrease he obtained from the twelve maps of the monthly isothermals the mean of thirty-six points, which he calls in each case the *normal temperature* of the parallel—that is, that which it would have everywhere if its actual temperature were uniformly distributed. From his temperature-curves and tables the following facts are deduced:—1. The mean annual temperature derived from the twelve monthly means agrees very nearly with the mean between the warmest and the coldest months. 2. The decrease of temperature, in advancing from the equator towards the pole, is least near the equator, and becomes progressively greater to about latitude 45°. The temperature of the equator is 79°.8, and that of the pole 2°.2, the difference on the mean of the year being therefore 77°.6: the difference of temperature between the equator and the pole is 48° in July and 106° in January. 3. The temperature of the pole rises in July to 30°.6 Fahr., or nearly to that of melting ice, and in January it sinks to 58°.6 below freezing. 4. From the pole to latitude 40°, July is the warmest month. The temperature of August then becomes equal to that of July; in the latitude of 30°, August is the warmest; in latitude 20° the two months are again equal. In latitude 10° the maximum temperature falls in May, and at the equator the maxima fall in April and November, and the minima in July and at the end of December. 5. The warmest parallel does not coincide with the equator, but falls in the northern hemisphere, so that the parallel of 10° is slightly warmer than the equator. Up to latitude 40° south, the temperature of the southern hemisphere is lower than that of the northern.

Modifying Causes which prevent the Normal from being everywhere the Actual Temperature.—From these results it appears that the decrease of temperature, in advancing towards the poles, corresponds, on the whole, nearly to the conditions of the solar climate, both as regards the forms of the curves in different latitudes and their distances apart. But perturbing causes exist in the dissimilarity of the floor or base of the atmosphere, which base may be always solid, always fluid, or fluid at some seasons and solid at others. If the solid and fluid parts were distributed in zones parallel to the equator, the rate of decrease of heat would alter *per saltum;* but the absolute temperature would always be a fraction of the geographical latitude only. But as the character of the surface under the same parallel of latitude is different under different meridians, so the same temperature will be found in different latitudes; and since the heating effects of the solar rays are always different in different latitudes, the ocean and the atmosphere become unequally heated; and the equilibrium being disturbed, marine currents and winds are produced.

Influence of Oceanic Currents.—The thermic influence of a marine current depends on the difference of temperature at the place which it leaves and the place at which it arrives. The most influential constant currents in this respect are the Gulf Stream in the North Atlantic, and the Peruvian or Humboldt's Current in the South Pacific (see Plates 12, 13, 14). Both these currents tend to drive the isothermals more to the north than they would otherwise be found, the Gulf Stream carrying warm water towards the Arctic regions, and the Peruvian Current bringing cold water from the Antarctic regions towards the equator; and their continual action is distinctly recognised in the forms of the isothermals of the several months, as well as in the yearly isothermals.[1]

Influence of the Winds.—On the eastern side of the globe the wide continental mass of the Old World forms the floor or basis of the atmosphere. Here, as the equalising influence of the ocean is wanting, the only modifying element is to be found in the movements of the atmosphere. As the mountains of the old continent have a direction generally from east to west (see p. 11), they oppose those currents which are most influential in modifying climate, *i.e.* those which blow in the direction of the meridian; for the severe winter cold of a continent in the northern hemisphere is mitigated by south winds, and its summer heat is tempered by those from the north; but the central elevation of the land in Asia screens Siberia, and deprives it of the softening influence of south winds, and the same cause in summer deprives the lowlands of the Ganges of the cooling influence of currents from the north. Hence the cold winters of Siberia and the warm summers of Southern Asia. The different degree of severity in the winters of different years depends, in our latitudes, on the prevailing direction of the wind in each case, and the general preponderance of moist warm winds over dry cold ones is the reason why our winters are more frequently mild than severe. The yearly isothermals show that where the torrid zone presents a land surface, the temperate and cold zones have high temperatures, for the solid surface of tropical Africa corresponds with the convex summits of the isothermals in Europe, and the more generally liquid surfaces in the East or West Indies correspond to the concave portions of the isothermal lines in Asia and America.

On the Thermic Anomaly.—The causes which prevent the regular distribution of temperature being known, it is necessary to find a method of determining the amount of disturbance produced, by ascertaining the relation of the actual temperature of each place to the mean or normal temperature of its geographical latitude. Dove calls the difference between these the "thermic anomaly;" and by connecting together places of equal and similar anomaly, he obtains "thermic isabnormals." The isabnormals of annual mean temperature are drawn on the equatorial projection, and those for the extreme months, January and July, on the polar projection.

In these charts the "thermic normals," or lines which pass through places which are neither hotter nor colder than belongs to their latitude, separate spaces where the temperature is relatively too high from spaces where it is relatively too low. All places situated on the isabnormal of + 9 Fahr. for example (Atlantic), have temperatures which exceed in every case the mean temperatures of their geographical latitudes by + 9 Fahr.; and places on the isabnormal of — ·9 Fahr. (Siberia) suffer a corresponding depression of temperature below the mean or normal temperature of their latitudes. An increase or decrease of temperature exactly corresponding to a change of latitude can only be found by advancing along a thermic normal. In advancing towards the poles the most rapid decrease of temperature is found to take place near the middle of the relatively cold spaces, and the slowest near the middle of the relatively warm spaces. Isabnormals coincide with isothermals only when they are themselves parallel to the equator, and they differ more and more from isothermals as their direction approaches that of the meridians. The course of the isabnormals is chiefly determined by the alternation of land and sea, which alternation being more frequent in the northern hemisphere, causes a greater frequency of those lines there.

In *January* (see Polar Projection) the negative or relatively cold lines occupy the continents, and conform to their outlines, while the positive or relatively warm lines correspond to the seas. The parallelism of the lines with the west coast of Europe continues to the interior of Asia. The greatest relative decrease of temperature is found in advancing towards the middle of the cold spaces in a direction perpendicular to the coasts of the continents. The relatively warmest place in the northern hemisphere in January is situated, in Europe, between Jan Mayen and the Lofoden Islands, the excess of temperature being 45° Fahr.; and the next warmest place, relatively to its latitude, is the peninsula of Kodiak, North West America. The relatively coldest place in the northern hemisphere in January is near Yakutsk, in Siberia, the depression being —40° Fahr.; and the next coldest place is in America, latitude 70°, longitude 100° west, where the depression is —27° Fahr. In the Northern Pacific the positive isabnormals are thickly crowded along the American shore: they cover only a very narrow strip of coast at the foot of the Rocky Mountains, the normal line being almost coincident with the ridge of these mountains. In the Old World they are as closely crowded along the coast of Norway, but here the positive abnormals extend over the whole of the European portion of the continent, the line of normal temperature not being reached until arriving at the Ural Mountains.

In the southern hemisphere the abnormal influence is almost entirely that of oceanic currents. The South Atlantic and South Pacific are comparatively cold, and the South Indian Ocean and Australia comparatively warm: the temperature of the interior of Australia rises in January to an intense degree. In *February* the forms of the isabnormals are but little altered, except that the cold spaces have moved northwards, and the warm spaces southwards. In *March* the coldest point in North America has moved still farther north, and under the influence of the sun's increasing altitude there are developed in the interior of Northern Africa and Western India spaces of greatest heat, which are further enlarged in April, and unite in May. In *April* the American normal moves eastward; in the Kirghis Steppe the warm space gains on the previously cold space, and the cooling influence of the Mediterranean begins to appear. In *May* the cold space in America has been transferred to Labrador and its vicinity, owing to the quantity of ice drifting at this season from Baffin Bay and the coast of Greenland; and the warm space in the north-west of America has left the sea, and occupies a space on either side of the Rocky Mountains; the thermic normal touches the Spanish coast, and Central Asia is included in the warmth of Europe. In *June* the entire continent of the old world has an excess of temperature, except a narrow strip in the vicinity of Novaia Zemlia. In *July* all these phenomena are more strongly marked, and the American normal now skirts the European continent. The entire periodical change which takes place in the distribution of temperature is best seen by comparing together the isabnormals of the two extreme months, January and July, on the polar projection, where the space between Europe and America, coloured red in January, is blue in July, and *vice versa*—the places which were warmest having become the coldest. The whole phenomena, viewed in reference to its annual course, may be regarded as turning, as it were, on a pivot, the movement taking place from west to east in the first half of the year, and from east to west in the second half.

When the Sun attains a considerable meridian altitude, his influence always renders the solid surface warmer than the sea. The amount of this heating influence is modified, however, by the geological character of the land, and its vegetable covering or desert nakedness.

The shape of the isabnormals is thus complicated, and they are broken up into small detached portions, forming separate groups, no longer extending over great distances as in winter. Even small seas have now a cooling influence, while the temperature of deserts is disproportionately raised. The aerial currents drawn to various centres lose their steady uniform direction, and are far less important in their effects than during winter, when their influence prevails almost exclusively. In *October* the cold breaks decidedly over Asia from the north; and this month is also the turning-point for the southern part of the Asiatic continent, where the south-east trade-wind, drawn far to the northward of its natural limits by the abnormal heating of Northern Asia, and converted by the earth's rotation into a south-west monsoon, now gives place to the regular north-east trade-wind, which here assumes the name of the south-west monsoon. In *November* the western normal has retrograded to the coast of America, and the eastern normal has already passed to the westward of the Ural Mountains. In *December* the eastern normal includes a large portion of the interior of Africa, but its northern part is arrested in its progress, as in Europe the assaults of the cold are repelled by the now powerful influence of the Gulf Stream, and the descent of the upper or equatorial atmospheric current. The southern hemisphere is but little affected by these changes, for the oceanic currents maintain nearly the same influence at all seasons; only Australia shows its title to be regarded as a continent by too great cold when the sun is low, and too great heat when the sun is high.

Professor Dove remarks that since the normal must pass through the pole, it furnishes a limiting point for the enclosed isabnormals in regions to which man has not been able to penetrate; and as the pole can be approached more nearly in some places than in others, the isabnormal which passes through such accessible stations being known, affords a determination of the mean temperature of the entire parallel; and as this parallel must always be intersected by other isabnormals, we obtain the temperature at the points of intersection, and are thus enabled to prolong the isothermal lines into inaccessible regions.

Yearly Isothermals.—The maps of the annual isothermals on the equatorial and polar projections, are derived from the same numerical values from which the normal temperatures of the several months are deduced. The monthly means of 36 equidistant points of the parallels of 0, 10, 20, &c., have been combined by Dove into an annual mean, and the lines have been drawn according to the values so obtained. In both hemispheres the isothermals flatten as the outer limits of the trade-winds are approached. They become more curved in approaching either the poles or the equator. The increasing curvature of the annual isotherms, in approaching the poles, led to their being represented as encompassing two separate poles of cold; but Dove believes "that the isothermal lines of mean annual temperature enclose one connected space of greatest cold, stretching from Melville Island towards Icy Cape, but without reaching the latter, and without touching the pole. Therefore the displacement of the pole of cold from the Asiatic side in January to the American in July, and its return to Asia in the second half of the year, is an oscillation round a mean position." As regards the annual periodic variation in the decrease of temperature at the surface of the globe, he gives, as provisional values—

For January,	Northern Hemisphere, . .	48°.9
	Southern Hemisphere, . .	59°.5
	Earth, ...	54°.2
For July,	Northern Hemisphere, . .	70°.9
	Southern Hemisphere, . .	53°.6
	Earth, ...	62°.3

The temperature at the surface of the earth, taken generally, increases therefore from January to July fully 8° of Fahr. Taking the mean between the temperatures of January and July for the northern and southern hemispheres respectively, the northern hemisphere gives 59°.9, and the southern hemisphere 56°.5 Fahr., being 58°.2 Fahr. for the whole earth. As the sun, in returning from north declination, enters the southern signs, an increasing quantity of heat becomes latent, on account of the increasing proportion of water in the terrestrial receiving surface, and hence the above stated great periodical variation of the total sum of the temperature of the whole earth; and which we shall the more readily understand if we remember that the southern hemisphere presents a great preponderance of "sea climate"—therefore of warm winters and cool summers; and the northern hemisphere of "continental climate"—therefore of cold winters and hot summers.

The mild winter of the southern hemisphere, *plus* the contemporaneous hot summer of the northern hemisphere, necessarily gives a higher sum of temperature than the cool summer of the southern, *plus* the cold winter of the northern hemisphere. "The above-described relations appear to furnish the motive power in the machinery of the general atmosphere of the earth—in the periodical conversion of the aqueous vapours into a liquid form. In this manner the circuit of the fluid element—the essential support of all vegetable and animal life—no longer appears to depend on mere local coolings, or on the intermixture of atmospheric currents of different temperatures; but the unequal distribution of land and sea in the northern and southern hemispheres supplies an effectual provision, from whence it necessarily follows that the aqueous vapour, which from the autumnal to the vernal equinox, is developed to an immense extent over the southern hemisphere, returns to the earth, in the other half of the year in the form of rain or snow. And thus the wonderful march of the most powerful steam-engine with which we are acquainted, the atmosphere, appears to be permanently regulated." The irregular distribution of physical qualities over the earth's surface is here seen to be a preserving principle for terrestrial life. Prof. Dove considers the northern hemisphere as the condenser in this great steam-engine, and the southern hemisphere as its water-reservoir; that the quantity of rain which falls in the northern hemisphere is therefore considerably greater than that which falls in the southern hemisphere; and that one reason of the higher temperature of the northern hemisphere is, that the large quantity of heat which becomes latent in the southern hemisphere in the formation of aqueous vapour, is set free in the northren in great falls of rain and snow.

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[1] The Hudson Bay or Greenland Current, although more limited in extent, is as influential in lowering the temperature on the shores of North America as the Peruvian Current is on the south.

GEOGRAPHICAL DISTRIBUTION OF WINDS AND STORMS,

WITH TABLES OF REMARKABLE HURRICANES, FROM THE EARLIEST ON RECORD TO THE PRESENT TIME.

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INTRODUCTORY NOTE.

Currents of air, or winds, originate in any circumstance which tends to disturb the equilibrium of the atmosphere, as a change in its temperature or in the amount of aqueous vapour which it contains. Wherever two adjoining regions, or spaces, are unequally heated, there is produced an upper current of air proceeding from the warmer to the colder region, and an under current in an opposite direction. The difference of temperature between the polar regions and those in the vicinity of the equator, which is extreme, amounting to upwards of 82°, and nearly permanent, produces a constant exchange of air between them. Thus the cold and dense air of the polar regions seeks to replace the warm, rarefied air of the equator, which, ascending and forming an upper current, flows towards the north and south, in order to restore the equilibrium.

If the earth were in a state of repose, the winds near its surface would blow uniformly from the north and south in the respective hemispheres; but since the globe revolves on its axis from west to east with a velocity which increases more and more as the points on its surface approach the equator, where it attains a maximum of about 1000 miles an hour, it results that, in passing from higher latitudes, the cold particles of air arrive progressively in regions where the rotatory movement is more and more rapid; and since they have not time to assume the velocity due to the several parallels of latitude as they overtake them, they necessarily hang back and form currents flowing apparently in a direction opposite to that of the rotation of the globe, or from east to west. Thus by the combination of the rotatory movement of the earth, the difference of temperature at its surface, and the rapid condensation or expansion of atmospheric vapour resulting from this change of temperature,[1] the currents of air coming from the north and south in either hemisphere are modified in their direction, and deflected towards the north-east and south-east, forming the magnificent phenomena of the Trade Winds. The atmosphere which floats on the surface of the earth is in a state of almost perpetual motion; this movement, according to its velocity and direction, is termed a Gentle Breeze, a Storm, or a Cyclone.[2] Considered in regard to their duration, winds may be divided into *constant, periodical*, and *variable*. The first are known by the name of Trade Winds, the most remarkable of the second class are the Monsoons, and the third comprises those which do not enter into either of the two preceding categories.

Trade Winds.—The trade winds are so certain in their course, and navigation is so simple where they blow steadily, that for this reason the early Spanish navigators gave to the trade-wind region of the Atlantic, between Europe and America, the name of the "Ladies' Gulf." Where these winds are well established, the weather is constantly fine and the sky in general clear. If they suddenly cease, the sky lowers, and in certain localities rain and storms succeed, with a violence and a duration proportioned to the vicinity of the place to the equator; and it is remarked that their re-establishment is always by a violent re-action, or by an excessive fall of rain. The trade winds blow, with occasional interruptions and modifications, more or less regularly round the globe; but in general their influence is not felt within 100 miles of the shore, where they are affected by the vicinity of land:—in many places, as on the coast of Africa in summer and autumn, they are southerly, and assume the character of monsoon winds. On the north of the equator they blow from the E. to N.E., N.N.E., and N.; and on the south of the equator, S.S.E., E.S.E., and E.

The polar limits of the N.E. and S.E. trade winds extend generally on each side of the equator, in the Atlantic and Pacific Oceans, to the parallel of latitude 30° N. and S. But these limits vary greatly in different parts of the ocean, and at different seasons, because, being subject to the influence of temperature, they remove two or three degrees towards the north and south, according as the sun has north or south declination. Thus in spring they are nearest the equator, extending sometimes at this season not further from it than the parallel of 15° N.[3] The zone of the N.E. trades in the Atlantic Ocean extends, on an average, from about lat. 7° to lat. 29° N., a section of the globe composed of nearly one-third part of land and two-thirds water. The zone of the S.E. trades in the Atlantic is much broader than that of the N.E., and the S.E. trades blow with greater freshness; they sometimes extend to lat. 10° or 15° N., whereas the N.E. trades seldom blow south of the equator.

In the Pacific Ocean the trade winds first strike the sea in the parallel of about 30° N.; thence they blow N.E., and reach the belt of equatorial calms, which here merges into the monsoon region, in the vicinity of the Caroline Islands. Between the N.E. and S.E. trades a space intervenes, extending at different seasons from about 150 to 500 miles in breadth. Here the two winds meet with opposing forces so nearly balanced as to neutralise each other and produce a calm. But as the air of the trade winds has in each hemisphere traversed obliquely a large space of ocean, it is necessarily loaded with moisture, and hence this belt of calms, known to seamen by the name of the "Variables," is also the zone of constant rain, of baffling winds, and of electrical explosions.[4] Following the course of the sun, the belt of calms shifts its position during the year over nearly 17° of latitude, according to the season. In summer it stretches furthest north, where it remains several months, and then returns south, so as to attain its extreme southern latitude some time in March or April. In July and August it extends to between lat. 7° and 12° N., and in March and April between lat. 5° S. and 2° N. This system of calms which, in connection with the monsoons of the Atlantic and Pacific Oceans, is called "equatorial doldrums," has a powerful effect in retarding the voyage of vessels under canvass. Besides the great equatorial belt of calms, recent investigations[5] have confirmed the opinion that there exist, near the tropics of Cancer and Capricorn, belts of calms across the great oceans. On the equatorial side of these belts, the wind at the surface of the sea blows permanently towards the equator; while, on the polar sides, the prevailing direction of the wind on the surface of the ocean is towards the poles. On the polar side of the Capricorn belt the winds prevail from the N.W., and on the equatorial side from the S.E.; on the polar side of the Cancer belt the prevailing winds are from the S.W., and on the equatorial side from the N.E. Like the belt of equatorial calms, the calm belts of the tropics are variable both in breadth and in position, according to the season. The extreme vibration of the calm belt of Cancer is between the parallels of 17° and 38° N. This belt is known to American seamen as the "Horse Latitudes."[6]

Monsoon Winds.[7]—The promontory of India intruding itself into the region of the trade winds, interrupts the continuous westerly current of air, which is replaced by alternating currents from the N.E. and S.W. These change their direction as the sun passes the latitude of the place. On the Malabar coast, as the sun approaches from the southward, clouds and variable winds attend him; and his transit northward is in a week or ten days followed by that furious burst of thunder and tempest which heralds the rainy season. His southward transit is less distinctly marked; it is the sign of approaching fair weather, and is also attended by thunder and storm.[8] Monsoon winds prevail to a limited extent in several portions of the globe, as in the Gulf of Mexico, where the *nortes* or north winds blow from September to March; and on the coast of Mexico and Central America, where recent observations have ascertained the existence of regular monsoon winds;[9]—on the coast of Brazil, where in autumn (September to March) they blow from the N.E., and in spring (March to September) from the S.E. On the other side of the continent the monsoons of the Chile coast blow from the N. from May to September, and from the S. from October to May; on the coast of Africa, where, between the parallel of 13° N. and the equator, the trade winds are during the summer and autumnal months turned back by the heated plains of the interior, and blow as a regular southwardly monsoon during six months. The region of the ocean exposed to these winds is of a cuniform shape, having its base resting upon Africa, and its apex stretching over to within 10° or 15° of the mouth of the Amazon. These monsoons blow towards the coast of Africa from June to November inclusive, and bring the rains which divide the season in these parts;[10] in the Mediterranean, where the north winds (*Etesian winds* of the Greeks) attain their greatest force in summer. But these winds are most thoroughly established, and blow with the greatest regularity, in the Indian Ocean, especially on the north of the equator, where they extend from the coast of Africa to the east coast of the Bay of Bengal, and even to the China Sea; although in the northern portion of it they blow with less regularity. South of the equator, the monsoons extend to lat. 7° or 8° S. in the Indian Ocean. In general the monsoons blow towards the continent during summer, and in an opposite direction in winter. Thus, the period of the commencement of the S.W. monsoon, which prevails in the northern part of the Indian Ocean from April to October, corresponds to the season in which the sun, having attained a great north declination, has heated the soil of India; whilst in the winter of that hemisphere, when the sun has south declination, the opposite, or N.E. monsoon prevails. The monsoons blow in one direction during half the year, or rather from the middle of April to the middle of September, and in an opposite direction from the middle of October to the middle of March.

In the north of the Indian Ocean the S.W. monsoon commences in the middle of April and terminates in the middle of September. The N.E. monsoon succeeds, and continues from the middle of October to the middle of March or beginning of April. The S.W. monsoon brings rain and foul weather. The wind blows with greater force during this than during the N.E. monsoon, when the sky is generally clear. The zone of the S.W. and N.E. monsoons is comprised between the equator and the tropic of Cancer. It extends from the east coast of Africa to the coasts of India, China, and the Philippine Islands. Its influence is sometimes felt in the Pacific, to the vicinity of the Mariannes, *i.e.* to 145° E. longitude. In the north it is occasionally observed as far as the islands of Japan. Regular monsoons are established in the channel of Mozambique, from the parallel of the Bay of Sofala to the equator. On the east of Madagascar, the N.E. monsoon blows from November to April, and the S.E. from April to November, the latter being the fine season.

The limits of the monsoons are not uniform in all places, and they do not always change exactly at the same period of the year. In the Bay of Bengal the winds are more variable in force and direction than in the Indian Ocean, where storms occur very frequently at the change of the monsoons. On the south of the equator, the S.E. monsoon commences in the middle of April and terminates in the middle of September; it is replaced by the N.W. monsoon, variable to the W.S.W., which commences in the middle of October and ends in the middle of March. This latter monsoon is the period of squalls and foul weather.

The S.E. and N.W. monsoons blow within a zone comprised between the equator and the parallel of 8° or 9° of S. latitude; but on the coast of Australia, and in the west of the Pacific, this zone extends to the parallel of 20° or 30° S.

The N.W. monsoon rarely blows with force and regularity, except in the months of December and January, when it sometimes occupies a zone comprised between the parallels of 10° or 12° S., and those of 2° and 3° N. This monsoon is subject to great irregularity. The S.E. monsoon which prevails during the fine season on the south of the equator, may be considered as an extension of the S.E. trade-winds, which then extend to the equator, the sun being at that time near the tropic of Cancer. The part of the ocean where S.E. and N.W. monsoons blow with the greatest force and regularity, is the sea of Java, and thence towards the east to Timor, among the Moluccas, and towards New Guinea, in the Arafura Sea. These monsoons are experienced on the north coast of Australia, between Melville Island and Cape York, as well as in Torres Strait, where the N.W. monsoon begins at the end of October, and continues till March.[1]

The change of the monsoons occurs between the latter half of March and September, and the first half of April and October. This change takes place gradually, and is almost always accompanied by storms and tempests. When the monsoon is about to cease, the clouds in the upper atmosphere are observed to take a direction opposite to that in which it has been blowing, although several weeks sometimes intervene before the change is apparent at the surface of the sea. Monsoon winds penetrate far into the interior of continents, but then their direction is modified by the form and contour of coasts and islands, chains of mountains, and other causes. The direction of the monsoons determines the wet and dry seasons in India; the rainy season of the west coast corresponding with the S.W., and that of the east coast with the S.E. monsoon.[2]

Land and Sea Breezes.—These alternating winds, which prevail on the coasts of continents, and islands of the Indian Ocean, on the African coast and other places, are occasioned by the diurnal heating and cooling of the soil, the temperature of the sea remaining nearly uniform. They follow the course of the sun, on which they appear entirely to depend, occurring sooner or later according to locality. When most powerfully felt, the air at noon is found to have attained a temperature of 120°, while that of the sea rarely rises above 80°. The air, thus heated and expanded, ascends, and draws from the sea fresh supplies to fill its room: the current thus generated constitutes the sea breeze. During night, the temperature of the earth often sinks to 50° or 60°, cooling the conterminous air, and condensing, in the form of dew, the moisture floating around. The sea is now from 15° to 20° warmer than the earth, the greatest difference between the two existing at sunrise; the air then rushes in, and draws off a current from the shore, constituting the land breeze. The sea breeze commences gently at first, and gradually increases, attaining its greatest force at the period of *maximum* heat of the day. It declines with the decreasing heat of the evening, and at sunset there is an interval of calm. During night, when the land is colder than the sea, the land breeze prevails. It attains its greatest force at the period of the *minimum* temperature of the night. A knowledge of these winds is of great use in local navigation.

Prevailing North-Westerly and South-Westerly Winds.—Beyond the limits of the trade winds in the temperate zones of both hemispheres, are the regions of the prevailing south-westerly and north-westerly winds. These appear to be produced by the fusion of the return currents from W. to E., occasioned by the trade winds, with the currents flowing from the poles towards the equator. The winds which result from these must necessarily take a mean direction, depending on the relative force of the opposing currents of air; this direction, although very variable, is chiefly westerly. On the north of the equator, between the parallels of 30° and 60° north, it is variable to the W. and S.W. The prevalence of south-westerly winds in the temperate zone of the North Atlantic is proved by the difference of time occupied in the voyage of wind-propelled vessels from the north of Europe to North America, and that of the return voyage from North America to Europe. From Liverpool to New York the average is forty days, while from New York to Liverpool it is twenty-three days. Between Europe and America the S.W. winds prevail in the ratio of two to one. The mean direction of the prevailing winds in this zone, deduced from numerous observations,[1] is, for England, S. 68° W.; France, S. 88° W.; Germany, S. 76° W.; Denmark, S. 62° W.; Sweden, S. 50° W.; Russia, N. 87° W.; North America, S. 86° W. Russia is the only country in which the mean direction of the wind is a little to the N. of west. In the Atlantic Ocean the most prevalent direction of the winds is between S. 45° W., and S. 70° W. When the sun is in the northern hemisphere, they prevail from S.W. to W.S.W.; but when he is in the southern hemisphere, they blow from W.N.W. to N.W. This latter period is the season of squalls and foul weather between North America and Europe.

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[1] Mr Hopkins (on Atmospheric Changes) attempts to trace all the phenomena of the winds to the evaporation of water and the condensation of steam.

[2] See method for registering the force of the wind, in table, p. 64.

[3] These limits are distinguished by colours in the diagram, at the top of the sheet, from the Wind and Current Charts of Lieutenant Maury. From this it will be observed that the varying limit of the trade-wind belt is uniformly furthest north in June, and furthest south in December.

[4] See Rain Map of World, Plate 20.

[5] Maury's Wind and Current Charts.

[6] Vessels formerly engaged in conveying horses from New England to the West Indies were often detained in this calm belt for many days, when the large cargo of animals would exhaust the stock of water and become frantic with thirst. To save a portion, the rest were thrown overboard; hence the origin of the term "Horse Latitudes."

[7] Monsoon or *mausm*; in Malay, *musim*, from the Arabic word "*mausim*,"—fixed time or epoch, season, &c.

[8] See Dr Buist, *Trans. Bombay Geog. Soc.* Vol. ix. 1850.

[9] Maury's Sailing Directions.

[10] The discovery of this district of monsoons is a result of the investigations connected with Lieutenant Maury's Wind and Current Charts.

[1] "The littoral of New Holland is surrounded by an extensive belt or circuit of atmospheric circulation, varying with the seasons as regards its direction, but constant in motion and intensity."—Strzelecki, *Phys. Descrip. of New South Wales*, p. 168.

[2] See Notes to the Rain Map of the World, p. 66.

On the south of the equator, between the parallels of 30° and 50° S. it is observed that the winds blow periodically from S.W. to N.W.; that they vary from W. to N.W. when the sun has south declination; whilst during the rest of the year they are in general from W. to S.W., and are then accompanied by storms and foul weather.[2] In general they are very variable and inconstant. Between Cape Horn and the Cape of Good Hope, a north wind of several days' duration is succeeded by dull and rainy weather, but when the wind passes to the S. of W., the weather is clear and fine.

In the frigid zone of the Atlantic, comprised between the parallel of 60° N. and the pole, inclosed by Europe and North America, and containing the islands of Iceland and Spitzbergen, no regular succession of winds has been observed. The land, from its vicinity, and the snow and ice by which it is environed, exercises a varying influence on the currents of air, according to the season. North winds are, however, the most regular and dominant.

All the winds of this zone are accompanied by rain and snow, except during portions of June, July, and August, when the weather is tolerably mild during southerly winds, although accompanied by snow, rain, and fogs. The coldest winds are those from the N. and N.E.; but in June and July they frequently blow from the S.S.W., and sometimes with violence. During the months of April and May, south winds bring snow; during the rest of the year there are thick fogs and bad weather. At Spitzbergen, it has been observed that, during the early part of the year, the winds blow from the south, and that they are northerly during the remainder. S.E. and N.E. winds bring the greatest amount of snow. At Novaia Zemlia, from September to May, the winds blow from the north almost without interruption, while from May to August they are westerly.[3] On the coast of Greenland the winds are not periodical. From May to July the weather is fine, with changeable winds, chiefly from the S.S.W. The winds are variable till September. Rains are infrequent; storms rare, and of short duration. The coldest winds are from the N.E.[4] In the arctic regions, according to Parry's interesting series of observations, extending uninterruptedly from July 1819 to September 1820, between the parallels of 74° and 75° N.,[5] the winds are very variable and moderate at all seasons of the year. The number of days on which they blow from the different quarters, are as follow:—N. 111½; N.N.W. 56; N.W. 32; W.N.W. ½; W. 32; W.S.W. 1; S.W. 19; S.S.W. 2½; S. 14½; S.S.E. 8½; S.E. 12½; E.S.E. 8½; E. 19½; E.N.E.—N.E. 6; N.N.E. 10; calm, 11; variable, 21.

Captain M'Clure found the prevailing winds N.E. along the American shore of the polar sea. During his two winters' detention at Baring Island, he found S.S.W. winds invariably bring the greatest cold.

In Hudson Bay, it has been remarked that, from October to May, the prevailing winds are from N. to N.W.; and from June to October, S.E. to E. Strong northerly blasts prevail in spring and autumn.

Cyclones or Hurricanes.—The cyclones[6] of the Antilles, and those of the Indian Ocean and the China Sea, appear to be subject to fixed laws for each hemisphere, whether as regards their movements of translation, or their gyratory movements. These laws have been carefully deduced from observation, and verified by the experience of vessels exposed to storms at all seasons, and in all the known hurricane regions.[7] It is now fully ascertained that in both hemispheres the air in the cyclone rotates in a direction *contrary* to that of the sun. Thus in the northern hemisphere the course of the sun is from the E. by the S., W., and N.; and the movement of the air in a hurricane is in the opposite direction, or from the N. by W., S., and E. In the southern hemisphere, the course of the sun being from E. by N., W., and S., that of the cyclone is from the N. by E., S., and W. From the observations alluded to, the following general laws have been derived:—

1. Cyclones originate in the space between the equator and the tropics near the equatorial limit of the trade wind, during winter, when these winds are irregular, or at the change of the monsoons.[8] There is no instance on record of a hurricane having been encountered on the equator, nor of any one having crossed the line, although two have been known to rage at the same time on the same meridian, but on opposite sides of the equator, and 10° or 12° apart. In both hemispheres, during the early part of their course, storms move in a direction from E. to W., and in an opposite direction, or from W. to E., during the latter portion. In all cases they move obliquely in a direction from the equator towards the poles. *(See Diagram No. 4.)* In the N. hemisphere, the area of their commencement is comprised between lat. 10° and 20° N., and long. 50° and 60° W., on the borders of the narrow zone of calms and variable winds, which, as before explained, is always north of the equator, and corresponds with the zone of constant precipitation of rain and of electrical explosions.

2. They obey a double movement, one a gyratory movement, the other a movement of translation. North of the equator this gyratory movement is from right to left by the S., or in a direction *contrary* to the hands of a watch. *(See the small circle in the middle of the North Atlantic Ocean.)* On the S. of the equator, the movement is from left to right by N., or in a direction *coincident* with the hands of a watch. *(See the small circle in the Indian Ocean.)* The general movement of *translation* is in the form of a parabolic curve, of which the summit is towards the W., and the branches extended to the E. The summit of this curve is tangent to the meridian, about lat. 30° in the N. hemisphere, and about 26° in the S. hemisphere, coinciding with the polar limits of the trade winds. *(See the usual track of hurricanes in the Atlantic and Indian Oceans.)*

3. The point of departure of the storm is at the E. extremity of the curve, nearest the equator, in corresponding latitude with the declination of the sun. Thence the first half of the storm is directed westward, towards the summit of the curve, receding from the equator. It then follows this summit in a tangent to the meridian, and turns eastward, the second half of its course being at the greatest distance from the equator. *(See Diagram No. 4, at the foot of the Map.)* The cyclones or tyfoons of the China Sea are occasionally exceptional, since they follow, in certain cases, an opposite direction, —*i.e.* they approach the equator instead of receding from it.

4. The rate at which cyclones travel varies greatly, not only in different parts of the world, but even in the same localities, and at the same season. The cause of this difference of motion is not yet ascertained. In the West Indian and North American cyclones the highest rate is stated by Redfield to be 43 miles per hour,[9] and the lowest 9.5 miles per hour; mean, 26 miles. In the South Indian Ocean, the rate is estimated by Mr Thom at from 10 miles to little more than 2 miles per hour, and by Colonel Reid at from 7 to 12½ miles per day. Mr Piddington's researches show that about the "storm path" the rate of progression is only from 2½ to 1½ miles per hour. In the Bay of Bengal the rate varies from 2 to 39 miles per hour.[10] In the China Sea the observed rate is from 7 to 24 miles per hour, and in the Pacific Ocean probably from 10 to 12 miles per hour. Some cyclones move so very slowly that they may be almost "considered stationary, like waterspouts or desert whirlwinds."[11]

5. Cyclones vary in size from 50 to 500, or even 1000 miles in diameter, a medium size being most common. They occasionally dilate and contract in their progress, and while contracting they often augment fearfully in violence. In the West Indies, near the islands, they are sometimes as small as 100 or 150 miles in diameter; but on reaching the Atlantic they dilate to 600 or 1000 miles; the wind blowing a severe gale over the whole area; of true hurricane violence towards its centre; and the entire vortex, so whirling, travels over thousands of miles of track. In the South Indian Ocean Mr Thom thinks that hurricanes, when first discovered, are from 400 to 600 miles in diameter. Mr Piddington shows that they may be as small as 150 miles, and he agrees with Colonel Reid in supposing them to extend to 600 miles. In the Arabian Sea, cyclones are supposed to be under 240 miles in diameter. In the Bay of Bengal the usual size is from 300 to 350 miles, but they sometimes contract to 150 miles, at the same time augmenting in force. The tyfoons of the China Sea appear to vary in size from 60 or 80 miles to 3 or 4 degrees in diameter.

East winds are characteristic of a commencing hurricane; while, in general, west winds occur only in the latter portion of the storm, as decreasing winds; hence, in the northern hemisphere the most dangerous part of a hurricane is the advancing border of the right-hand semicircle, while in the southern hemisphere it is the advancing quadrant of the left-hand semicircle. *(See Diagram No. 4.)* The only chance of safety in navigating the hurricane regions lies in a careful observance of the indications of the barometer and simpiesometer. There is no authentic case on record of the occurrence of a cyclone in or near the tropics without some depression of the barometer, nor does any case of remarkable depression of the instrument ever occur without being followed by a storm.[12] The amount of this depression sometimes amounts to 2½ inches, the lowest indication being at the centre of the storm.

The effect of the rotatory movement of a cyclone is to accumulate the air around its outer margin, with a pressure increasing as it recedes from the centre; consequently the barometer is lowest at the middle of a storm area, and highest at its extremity. The barometer and simpiesometer oscillate before and during a hurricane, rising and falling rapidly, owing to the inequality of the pressure of the atmosphere which causes the storm, so that great barometric oscillations almost always announce the approach of a tempest. During a tyfoon in the China Sea in October 1840, in which the transport *Golcondah*, with three hundred troops on board, foundered, the simpiesometer in another ship, which avoided it, was observed to oscillate for twenty-four hours before the cyclone.[1] The barometer is observed to rise before the strength of the cyclone is over, and this beautiful indication, as Mr Piddington observes, is often to the seaman a rainbow of hope in the depth of his distress.

Two classes of cyclones have been observed, one in which the fall of the barometer is more or less gradual, and another in which the fall is sudden and excessive, and the tempest furious in proportion. This rapid fall appears to begin at from 3 to 6 hours before the passage of the centre. The fall of the barometer varies according to the intensity of the storm: in an extreme case it fell more than 2½ inches, or from 29.9 to 26.30.[2]

Previous to the commencement of a cyclone the wind is observed to be moderate or calm, the air close, sultry, and oppressive. The wind then rises and falls with a moaning sound, and a few hours after its commencement it is succeeded by a lull, which lasts for an hour or more, after which the wind blows from the same quarter with increased violence. The hurricane is usually accompanied by an excessive accumulation of aqueous vapour, developing electrical explosions in incessant flashes of lightning. In cyclones of considerable extent the swell of the ocean is often felt as a double sea, one preceding the track or the wave of progression, which is driven before the storm, and the other the cyclonal wave, or that which is occasioned by the wind on different parts of the storm circle.[3]

Seasons of Cyclones.—Little is yet known of the exact times at which hurricanes occur in different parts of the world, except in the West India region, where they appear to be influenced by season, both as to their frequency and their direction. It has been observed that they occur most frequently near the close of the rainy season, when the sun is vertical to the place of their origin. In the North Atlantic they occur from the end of June to the middle of December, but the greatest number occur in August.[4] In the Indian Ocean the chief period of their occurrence is from November to June; they are most frequent in January and March, and least so in June and November. The cyclone season of the Bay of Bengal is in October and November, when the N.E. monsoon blows with greatest violence. Storms also occur during the S.W. monsoon in May and June. In the China Sea the tyfoon cyclones occur nearly at the same season as the West India hurricanes *(see Table below,)* from June to November; the maximum being in September, and the minimum in June. In the Arabian Gulf, cyclones occur during both monsoons.

A knowledge of the exact localities visited by these devastating storms, and the periods of their recurrence, is of such paramount importance to the safety of navigation, that we have been induced to collect and to condense in chronological order all those of which authentic records exist from the earliest times.

THE AVERAGE NUMBER OF CYCLONES, OR HURRICANES, WHICH HAVE OCCURRED IN DIFFERENT MONTHS OF THE YEAR, AND IN VARIOUS REGIONS, MAY BE THUS STATED:—[5]

Locality.	For what No. of years ascertained.	Months.											
		Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.
West Indies,	334		1	2			4	15	36	25	27	1	2
South Indian Ocean,	29	9	13	10	8	4				1	1	4	2
Mauritius,	24	9	15	15	8								6
Bay of Bengal,	46	1		1	1	7	3		1		7	6	3
China Sea,	64						2	5	5	18	10	6	

CHRONOLOGICAL TABLE OF THE PRINCIPAL HURRICANES WHICH HAVE OCCURRED IN THE WEST INDIES WITHIN THREE HUNDRED AND FIFTY-FOUR YEARS.

, The Roman numerals refer to hurricanes, the courses of which are traced on the small Chart No. 1.

Date of Occurrence.	Localities Visited.	Remarks.
1493, February 12.	North Atlantic.	Experienced by Columbus on his first homeward voyage. This is the earliest hurricane on record.
1494, June 16.	South side of Cuba.	Described by Peter Martyr. The ships of Columbus, on his second voyage, were lost in this storm.
1502, July 1, 2.	San Domingo.	Columbus exposed to the storm. 20 sail of Spanish vessels with all on board perished.
1502, December 5.	Puerto Bello.	This storm, according to Columbus, lasted 9 days; it was accompanied by a waterspout.
1508, August 3.	San Domingo.	The storm blew first from the north, and shifted suddenly to the south. Nearly all the houses in San Domingo and Bonaventure were blown down, and 20 sail of vessels destroyed.
1509, March —.	Gulf of Mexico.	*Nortes* or *Norths*, first noticed by Hernandez de Cordova. The storm lasted 4 days.
1509, July 10.	San Domingo.	The city again nearly destroyed.
1526, October —.	San Domingo.	During a violent hurricane the rivers overflowed their banks.
1527.	Cuba.	The expedition under Navarez was partly destroyed by a hurricane this year.
1530.	San Juan and Porto Rico.	Hurricanes very severe this year; rivers overflowed; drop-trees, and herds washed away. The works at the gold mines suspended.
1591, August 10.	In lat. 35° N.	A fleet of 77 sail from Havana, bound for Spain, overtaken by a storm from the north; the admiral's ship, with crew of 500 men, foundered; a few days after, in another gale, 5 or 6 of the largest ships with all their crews were lost.
1623, September 19.	Windward Islands.	The tobacco crops of the first settlers destroyed at St Christopher.
1642.	St Christopher, &c.	Three hurricanes recorded this year, but not detailed; in one of these, 23 fully-laden vessels were wrecked.
1651.	Martinique.	
1652.	Caribbean Sea.	Prince Maurice was lost in a hurricane this year, in which the fleet of his brother Prince Rupert suffered severely.
1656.	Guadeloupe.	The island desolated; most of the houses destroyed, all domestic animals killed and plantations laid waste; every vessel in the roads wrecked, and most of their crews drowned.
1657.	Guadeloupe.	After a severe hurricane, immense numbers of caterpillars appeared and destroyed the vegetation spared by the storm.
1664.	Guadeloupe.	The provision crops destroyed, and an earthquake at St Christopher did great damage.
1666, August 4, 5.	Guadeloupe, St Christopher, Martinique.	This hurricane lasted 24 hours; houses and trees were blown down, and cattle killed; the sea rose to an unusual height. Batteries with 6 feet walls and large guns washed away, and every vessel and boat on the coast of Guadeloupe was dashed to pieces. Of Lord Willoughby's fleet of 17 vessels, which left Barbadoes on the 28th July with 2000 troops, only two were ever heard of afterwards. The whole coast was strewed with wrecks, among which a figure from the stern of Lord Willoughby's ship was recognised. In consequence of these disasters and the great fire in London, this was called the dismal year of 1666.
1667, September 1.	St Christopher.	A tremendous hurricane commenced at 9 A.M. and lasted until 5 P.M. All the buildings were blown down, and vegetation destroyed.
1670, October 7.	Jamaica.	The English fleet driven on shore during a hurricane.
1674, August 10.	Barbadoes.	
1675, August 31.	Barbadoes.	Nearly every house and tree were swept away. 8 ships, laden with valuable produce, sunk.
1681.	Antigua.	
1692, June 7.	Jamaica.	Port-Royal was destroyed by an earthquake, by which 3000 individuals perished. The whole island shared in the devastation, which completely changed its surface. This was shortly after succeeded by a hurricane.
1694, October 17.	Barbadoes.	Most of the vessels in Carlisle Bay were stranded.
1695, October 2.	Martinique.	The hurricane was accompanied by an earthquake.
1707.	Nevis.	This year the inhabitants were nearly ruined by a severe hurricane.
1712, August 28.	Jamaica.	This storm was accompanied by an earthquake. Savana-la-Mar was in a few moments submerged by the sea, and swept from the face of the earth. Not a single habitation escaped, and not an individual survived to relate the calamity.
1714, August 13.	Guadeloupe.	
1714, August 29.	Jamaica.	Some men of war were driven ashore in this storm.
1722, August 28.	Jamaica.	This hurricane, like that on the same day of the month 10 years previously, was extremely disastrous. Port-Royal was overwhelmed by the sea, and 26 vessels and 400 persons perished in the harbour.
1726, October 22.	Jamaica.	This storm lasted only 3½ hours, yet many of the houses in Kingston, Spanish Town, and Port-Royal were blown down, and 50 vessels were destroyed.
1728, August 19.	Antigua.	
1731.	Barbadoes.	A shoal near the land, 200 yards long and 20 broad, was covered with a bank of stones 4 feet thick.
1737, September 9.	San Domingo and Montserrat.	The town of St Louis and the plantations entirely destroyed, and all the ships at anchor were stranded.
1740.	Antigua and Martinique.	These islands suffered severely from a hurricane this year.
1744, October 20.	Jamaica.	A fearful storm raged from 6 P.M. till 6 A.M. next day; wind due S. Mosquito Fort (Augusta) was demolished, 8 men-of-war and 96 merchant-vessels were stranded, wrecked, or foundered. Of 105 vessels, only one (H.M.S. *Ripon*) rode out the gale, and she was dismasted. Among the wrecks was the *Lark*, in which 110 persons perished.
1747, September 21. 1747, October 24.	Leeward Islands.	Most of the islands suffered. 14 sail of merchantmen were lost at St Christopher, and 30 among the other islands.

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[1] Kämtz, Meteorology. [2] Nicholson. [3] [illegible] [4] [illegible]

[5] *Voyage of the Hecla and Griper.* London, 1821.

[6] The word *cyclone*, the accepted term for whirlwind, is proposed by Mr Piddington to designate a wind blowing in a circuit, whether a circle or an ellipse, or a wind describing a spiral by its progression while turning.

[7] The following are the principal authorities on the subject of Storms:—Col. Capper on Winds and Monsoons; London, 1801. W. C. Redfield, Esq.; papers in American Journal of Science, and in London Nautical Magazine, 1831 to 1848. Col. Reid, Attempt to Develope the Law of Storms, third edition, London, 1850; and Progress of the Development of the Law of Storms, second edition, London, 1849. H. Piddington, Memoirs on Storms, Journal Asiatic Society of Bengal, 1839 to 1849. The Hornbook of Storms for the Indian and China Seas, 1844 to 1847. Sailors' Hornbook for the Law of Storms, second edition; London, 1851. J. P. Espy, The Philosophy of Storms; Boston, 1841. Alex. Thom, M.D., Inquiry into the Nature and Course of Storms; London, 1845. W. R. Birt, Handbook of the Law of Storms; Liverpool, 1853. M. F. A. E. Keller, Des Ouragans, &c.; Annales Maritimes et Coloniales; Paris, 1847. Des Typhons, ib. 1849. Lieut. Maury's Sailing Directions; Washington, U.S. 1853-4.

[8] Of 127 hurricanes which occurred in 354 years, as explained in the table, 4 occurred in June.

[9] The hurricane of Cuba, October 1844.

[10] Mr Piddington observes this latter rate occurred only in one instance, and that from 3 to 15 miles may be taken as the usual rates.

[11] Sailor's Hornbook, p. 72.

[12] Humboldt observes that hurricanes are not in general accompanied by such an extraordinary lowering of the barometer as is imagined in Europe. He instances 56 barometric observations made nearly from hour to hour, at the Havana, during the great hurricane of August 1794, in which, at the most violent part of the storm, the column of mercury sank only five lines.—*Personal Narrative*, vol. vi. p. 746. This appears to be an exception, however; for Kirwan states, that in the hurricane at St Bartholomew, in 1792, the mercury sank equal to 1.65 English inch.

[1] Piddington. [2] Col. Reid. Journal Asiatic Society of Bengal. [3] Sailor's Hornbook, p. 78.

[4] See note at foot of table, p. 63. [5] See Handbook of Storms, p. 290.

Date of Occurrence.	Localities Visited.	Remarks.
1754, September.	San Domingo.	12 ships were driven on shore, and 1700 hhds. of sugar destroyed.
1756, September 12.	Martinique.	
1759, September.	Gulf of Mexico.	A storm from the NE. so impeded the current of the Gulf Stream that the sea rose to such a height as to cover the Tortugas and other islands.
1765, July.	St Eustatia, &c.	33 ships were lost at Martinico, and 6 at Guadeloupe.
1766, August 13.	Martinique.	A dreadful storm from the NW., accompanied by an earthquake, &c.
1766, September 13-15.	St Christopher and Montserrat.	The storm was accompanied by a waterspout, in which 28 French and 7 English vessels were wrecked; 90 persons perished, and nearly 200 were wounded.
1766, September 21.	St Eustatius and Tortugas.	
1766, October 6.	Dominica.	
1768, October 25.	Havana.	During the two hours' continuance of this terrible hurricane, 98 public edifices and 4048 houses were destroyed. More than 1000 persons perished almost instantaneously.
1772, August 4, 5.	San Domingo.	
1772, August 28.	Porto Rico.	
1772, August 31.	Leeward and Virgin Islands.	In this storm, which commenced from the NE., and shifted suddenly to SW. by S., H.M.S. *Chatham*, *Active*, *Sea Horse*, and *Falcon* were driven ashore in English Harbour, Antigua. In several other islands the destruction was complete. At St Christopher the damage was estimated at £500,000 sterling. At St Eustatia, 400 houses were destroyed, and the Dutch church was blown into the sea. At Dominica 18 vessels were driven ashore and lost. At Santa Cruz the sea rose 75 feet above its usual level, and swept all before it; nearly all the houses were levelled. Every ship at the island was driven ashore, some of them 100 yards inland.
1774, October 20.	Jamaica.	
1776, September 5, 6.	Martinique and Guadeloupe.	
1780, October 3, 4.	Jamaica.	Several men-of-war foundered and were wrecked; the town of Savana-la-Mar was swept away by the sea, and 300 persons perished.
1780, October 10, 12.	Barbadoes.	This storm lasted 48 hours. All the ships were driven from their anchors. Bridgetown was nearly levelled with the earth—(a 12-pounder gun was moved a distance of 140 yards.) Almost all the live-stock and 4326 persons perished. Many of the other islands suffered, and numerous vessels were lost. (xii.)
1781, August 1.	Jamaica.	Many small vessels were lost. On the 2d, H.M.S. *Pelican* was wrecked on the Morant Keys.
1784, July 30.	Jamaica.	Only 4 vessels in Port-Royal escaped; all the others were sunk or driven on shore, and many lives were lost. The barracks at Up-park were blown down.
1785, August 27.	Jamaica.	
1785, August 31.	Guadeloupe.	
1786, September 2.	Barbadoes.	Every vessel in Carlisle Bay was driven ashore, and many persons were killed by the falling houses.
1786, October 20.	Jamaica.	The trees were entirely stripped of their leaves, and the shores were covered with aquatic birds that had been dashed against the mangroves and killed.
1787, August 3, 23, 29.	Dominica.	All the vessels at the island were destroyed, and the barracks blown down.
1788, August 14.	Martinique.	20 vessels were driven ashore and lost. A mansion-house, with its inmates, was removed to some distance, with little injury.
1790, August.	Nevis.	
1791, October 29.	Jamaica.	
1792, August 1.	Antigua, &c.	Several plantations destroyed.
1793, August.	St Christopher.	30 vessels were driven from the roads, or stranded.
1794, August 27, 28.	Havana.	Several vessels wrecked.
1795, August 10.	Jamaica.	
1795, August 18.	Antigua.	
1796, October 3.	Bahamas.	
1801, July 22.	Nassau.	120 sail driven on shore and wrecked.
1804, September 3.	Windward Isles.	This storm commenced at Antigua; passed N. 48° 6′ W., travelled 590 miles in 38 hours, or at the rate of 15½ miles an hour. It was off Charleston on the 7th, and at Boston on the 9th. (iv.)
1804, September 3-6.	Leeward Islands.	274 vessels said to have been lost by this storm.
1805, July 27.	Jamaica.	
1805, July 29.	N. of Barbadoes.	In this storm H.M.S. *Centaur* was dismasted; it lasted 24 hours.
1806, August 30.	Bahamas.	This storm commenced at Eleuthera at 8 p.m.; it entirely destroyed vegetation. On September 13 a more severe gale threw down the houses, and tore up the trees by the roots. These were followed by a severe hurricane on the 27th September, and another on the 5th October of the same year.
1806, September 9.	Dominica.	Almost every house was blown down, and 457 persons killed. 16 vessels lost, with 146 persons. H.M.S. *Franchise* and *Penguin*, with a fleet of 100 merchant ships, were overtaken by the storm, 13 of the ships foundered, and 70 persons perished.
1806, October 5.	Barbadoes.	
1807, July 25.	St Christopher.	
1809, September 2.	Porto Rico.	H.M.S. *Lark* foundered. The storm lasted 14½ hours.
1810, August 12.	Trinidad.	
1812, October 14.	Cuba.	At Trinidad 500 houses destroyed, and many vessels driven ashore or sunk in the harbour of Casilda.
1813, July 22, 23.	Dominica, &c.	At St Christopher all the ships were driven ashore.
1813, July 26.	Bermuda.	In the harbour of St George 60 vessels were stranded.
1813, July 31.	Jamaica.	
1813, August 1.	Jamaica.	
1815, September 1.	St Bartholomew.	30 sail of vessels driven ashore, 14 of which were totally lost.
1815, September 20.	Turk's Island.	Half of the houses on the island blown down, and several vessels wrecked.
1815, October 18.	Jamaica.	Great damage to the houses in Kingston and the shipping in the harbour.
1816, October 16, 17.	Dominica, &c.	
1817, September 17.	Dominica.	
1817, October 21.	St Vincent, &c.	The shipping in Barbadoes suffered severely. General Seymour and many others perished in the fall of the Government house of St Lucia.
1818, September 27.	Barbadoes, &c.	
1819, Sept. 21, 22.	Virgin Isles, Porto Rico, &c.	
1819, October 13, 15.	Barbadoes.	This was the most severe hurricane since that of 1780; the water rose in the streets 4 to 5 feet.
1821, September 1.	Bahamas.	Passed over Carolina, Massachusetts, &c. On the same day a hurricane at Guadeloupe destroyed 200 lives. (viii.)
1822, March 11.	Jamaica.	
1822, December 18, 19.	Barbadoes.	
1825, July 26.	Dominica, Martinique, &c.	6 villages were destroyed at Porto Rico, and many lives lost in Basse-Terre.
1825, October 1.	Cuba.	
1827, August 17.	St Martin and St Thomas.	(iii.)
1827, August 28.	Virgin Isles.	
1828, September 18.	N.W. of Bermuda.	H.M.S. *Acorn*, *Contest*, and *Sappho* lost.
1830, August 12.	St Thomas.	(vi.)
1830, August 22.	N. of the Bahamas.	It reached the coast of the United States on 24th, 25th, and 26th. (ix.)
1830, September 29.	The N. side of the Caribbee Islands.	(vii.)
1831, June 23.	Trinidad, Tobago, &c.	(i.) This storm extended to Yucatan.
1831, August 10.	Barbadoes.	By this awful visitation the whole face of the country was laid waste; 2500 persons perished, and 5000 were wounded. The force of the wind may be estimated by the fact, that a piece of lead 400 lb. in weight was lifted and carried to a distance of 1800 feet. (ii.)
1832, June 6.	Bahamas.	
1832, August 7.	Jamaica.	Lasted only three hours, but was extremely violent.
1834, October 20-21.	Martinique.	
1835, July 26.	Barbadoes.	Twenty-one sail of merchantmen were driven ashore and wrecked.
1835, August 12.	Antigua, St Thomas, &c.	(v.)
1835, September 3.	Barbadoes.	
1837, July 26.	Barbadoes, &c.	At Antigua and St Christopher several vessels were wrecked, and at St Thomas' thirty-six were lost. (xiii.)
1837, July 31.	Antigua, St Thomas, &c.	Many vessels wrecked and houses blown down. (xiv.)
1837, August 6.	Little Antilles.	(xv.)
1838, September 7, 8.	Bahamas.	In this storm, memorable for the varying force of the wind, H.M. surveying vessels *Thunder* and *Lark* were exposed on the Great Bahama bank.
1838, November 1.	Vera Cruz.	Three United States vessels were lost, and the crews of two of them perished.
1839, September 11.	Bermudas.	H.M.S. *Victor* foundered in this storm.
1842, July 12.	United States.	This storm passed over Washington; upwards of thirty vessels went ashore near Cape Hatteras.
1844, October 3.	Jamaica.	This hurricane passed over Havana on the 4th, where it raged furiously. It is supposed to have reached Canada on the 9th and 10th. On Lake Erie, 100 houses were blown down, and 50 persons perished.
1845, October 12.	Florida Channel.	The royal mail steamer *Avon* was overtaken in this storm; it lasted 48 hours.
1846, October 11.	Florida, Havana, &c.	The hurricane commenced in the morning at Key West; the tide rose rapidly, and the storm raged until midnight; nearly all the houses were blown down, and the loss of life was very great. The lighthouses at Key West and Sand Key were swept away, with their inhabitants. U.S. ship *Perry* and 20 other vessels were hove on the reef.
1847, October 11.	Tobago.	Nearly 800 houses were destroyed or injured, and 17 lives were lost.

The above table records the appearance of 127 cyclones or hurricanes in a period of 354 years. Of these, there occurred in February, 1; March, 2; June, 4; July, 15; August, 36; September, 25; October, 27; November, 1; December, 2. It has been generally supposed that the islands of Trinidad, Tobago, and Grenada, are beyond the hurricane regions; but this is shown to be a mistake, for in the year 1831 we find the first, and till then the only, instance of a hurricane in the month of June.

CHRONOLOGICAL TABLE OF THE PRINCIPAL HURRICANES WHICH HAVE OCCURRED IN THE INDIAN OCEAN AND CHINA SEA, DURING A PERIOD OF TWO HUNDRED AND FIVE YEARS.

Date of Occurrence.	Localities Visited.	Remarks.
1648, May 16.	From Bombay, northward.	Accompanied by an earthquake.
1737, October 7.	Mouth of the Ganges, to 60 miles up the river, which rose 40 feet above its usual level.	20,000 craft destroyed; 8 English ships, with most of their crews, lost in the Ganges; 30,000 people said to have perished in Lower Bengal, or in the gulf; an English church and steeple sunk into the earth next morning.
1746, December 6.	Madras Roads.	6 French men-of-war blown out of Madras Roads, one of them foundered, 4 dismasted; 20 other vessels driven ashore, or lost at sea.
1760, December 30.	Pondicherry.	This hurricane happened during the siege of Pondicherry, when several of the ships were driven on shore.
1773, October 26.	Madras Roads.	The storm blew with incessant violence for 14 hours, with nearly equal strength, from every point of the compass. All the vessels at anchor were lost, and almost every person on board perished.
1774, April 13.	Coromandel Coast.	Set in as the English were about to march on Tanjore; the camp blown down, and tents torn into rags; 2 Indiamen stranded. The *Apollo*, hospital-ship; the *Bentinck*, 60 guns; and *Namur*, 74, lost, with nearly all on board.
1800, October 19.	Ongole.	This furious hurricane was accompanied by an earthquake.
1808, November.		The *London*, *Nelson*, *Experiment*, and *Glory*, East Indiamen, parted from the fleet, and never more heard of; supposed to have gone down in a hurricane, and all on board perished.
1809, March.		*Duchess of Gordon*, *Calcutta*, *Bengal*, and *Lady Jane Dundas*, parted from the fleet in a hurricane, and supposed to have foundered; all hands perished.
1822, June.	Mouth of the Ganges.	In this terrible storm, and in the consequent inundations of the Burisal and Backergunge, upwards of 50,000 souls perished, with a vast amount of property in houses, cattle, &c.
1823, May 28.	Bay of Bengal.	Six large English ships wrecked.
1832, October 7.	Mouth of the Ganges.	This storm, though of short duration, was of appalling violence, and was remarkable for the oscillations of the barometer, which fell from 29.78 to 29.16 inches.
1833, May 21.	Mouth of the Hoogley.	In this awful storm, the tide rose more than 12 feet above the ordinary springs of the season, sweeping over the land, destroying all the bunds and villages, with the population, and cattle. Among the wrecks which strewed the shore was that of the H.E.I.C. ship *Duke of York*, which was carried far inland. The fall of the barometer (2¼ inches) is the greatest on record.
1837, June 15.	Bombay.	Immense destruction of property, and loss of shipping in the harbour, estimated at £90,000; upwards of 400 native houses destroyed.
1839, November 16.	Off Coringa and Madras.	From Coringa to Madras the whole coast was strewed with wrecks and ruins. Although the storm lasted only 5 or 6 hours, 20,000 people are supposed to have perished.
1840, April 28 and May 1.	Cuttack.	This storm originated E. of the Andaman Isles.
1840, May.	Madras and South Coast.	
1840, Sept. 24, 27.	China Sea.	The *Golconda*, with a detachment of the 37th Madras Native Infantry, 200 strong, on board, is supposed to have been lost.
1842, May 3, 4.	Calcutta.	Every ship, boat, and house more or less injured.
1842, June 3.	Calcutta.	Almost every house in the town and vicinity injured. The barometer sank to 28.278, the lowest ever known at Calcutta.
1842, October 2.	Pooree.	The gale commenced with rain, and was accompanied with thunder and lightning. The damage done at sea and on shore was immense.
1842, October 22.	Madras, and across Arabian Sea as far as Aden.	This storm moved nearly due W. (contrary to the usual course of storms in this quarter) to Pondicherry, then S.W. over the peninsula. On reaching the ocean on the W. its course was W.N.W. to the coast of Arabia. (*See Diagram No.* 3.)
1845, February 22, 27.	Mauritius.	
1846, May 29.	Loodiana.	The barracks of H.M.'s 50th regiment fell in, and 84 men, women, and children were killed on the spot, and 115 wounded.
1847, April 19.	From the equator N. to Scinde.	H.E.I.C. ship *Cleopatra* lost, with 150 souls on board; the Maldive Islands were submerged, and severe want and famine succeeded.
1848, April 23.	Off Ceylon.	H.M.S. *Jumna*, from Bombay, nearly lost. She had an obelisk and other valuable Assyrian marbles on board.
1848, May 26.	N.W. India, over an area of 10,000 miles.	A furious storm of thunder, lightning, wind, and rain lasted for two nights continuously. Simultaneously with this, an earthquake of unusual violence prevailed from Surat to Simla, the most severe in this quarter since 1819. An exactly corresponding phenomenon occurred on the 16th May 1848.
1848, Sept. 12, 14.	Bay of Bengal.	
1849, July 22-26.	All over India.	A violent storm of rain burst all over India: a hurricane swept the Jullundher, carrying everything before it. The barracks of H.M.'s 32d at Meerut, and those at Ghazeepore, destroyed. On the 25th, 10 inches of rain fell at Bombay, and in the course of 4 days 26 inches fell at the Phoonda Ghaut, and 40 inches at Mahableshwar.
1849, December 10.	Madras.	The ships *Lady Sale*, *Industry*, and *Princess Royal* lost.
1851, May 1.	Off Ceylon.	
1851, May 6.	Madras.	The storm swept across the peninsula, and sent up a tremendous swell towards Scinde; the ship *Charles Forbes* lost in the Strait of Malacca.
1851, October 21, 22.	Calcutta and vicinity.	Shipping off Diamond Harbour and below Saugor greatly damaged; the *Bengalee* and *Scarfeld* wrecked, crews of both saved; the *Precursor*, a powerful steamer, and 5 sailing vessels, driven ashore.
1851, November 22.	Goojerat, Cutch, and Lower Scinde.	The steamer *Surat*, which left Bombay for Kurrachee on the 19th, sunk; no vestige of her ever appeared; all on board, 120 souls, perished.
1852, May 14.	Calcutta.	During this storm the barometer sank to 29.362. It was the most severe since 3d June 1842. 2657 thatched, and 526 tiled houses, and 40 substantial buildings were destroyed. 11 persons killed and 2 wounded.
1852, May 17.	Cape of Good Hope.	During a severe gale the barometer fell to 29.42 (temp. 60), the lowest known since 21st April 1848, when, without any change in the weather being experienced, it sank to 29.38, the lowest on record at Cape Town.
1853* March 27, 28.	Coromandel Coast.	Nearly 50 vessels were wrecked or sunk in this storm.
1853, June 21.	Off Bombay.	The Arab ship *Nusser* was lost off the harbour, and 300 persons drowned.
1853, October 10, 12.	Between Hong Kong and Singapore.	

* The year 1853 was remarkable for the absence of storms in India.

The courses of several of the best ascertained of the West India cyclones are delineated in the small Chart, No. 1, at the foot of the sheet. From this it appears that the track of the greater number of these hurricanes forms part of an elliptical or parabolic circuit, from which, indeed, very few of them diverge. It shows also the very striking fact, that the vortex of the curve is uniformly found in or near the parallel of latitude 30°, which parallel also marks, nearly, the external limits of the trade wind on both sides of the equator. It is further worthy of remark that by this parallel of 30° the surface area of the globe, as well as its atmospheric covering, is almost equally divided, the area between this parallel and the equator being nearly equal to that of the entire space between it and the pole.

Tropical Storms.—(*See the small Chart, No. 3, at the foot of the Plate.*)—As an illustration of the counter-movements of storms in the northern and southern hemispheres, we have placed together on the same diagram the tracks of two well-authenticated cyclones, which occurred in nearly the same meridian, but on opposite sides of the equator. The first, as traced by Mr Piddington, and described by Colonel Reid,[1] appears to have originated at the Andaman Islands on the 22d October, and to have moved in a direction W. by N., across the Bay of Bengal, its centre passing over Pondicherry. Its course thence was across Southern India to the Arabian Sea, turning more to the north as it approached the shores of Arabia, near which the ships *Seaton* and *Chieftain* were overtaken by it, as marked on the diagram. This hurricane furnishes an illustration of Mr Redfield's observation, that "storms which pass from elevated lands, or even from low countries, do not often act with great force at the surface of the ocean, till at a considerable distance from the coast; this being especially the case with that side of the storm which exhibits an off-shore wind." Its course appears to have been deflected southwards by the range of the Ghauts, as shown by the smaller circle on the Plate, and, modified by this interruption, it lost its whirlwind character for a time, till it had proceeded some distance from the land, but it had resumed this character when the ship *Futtay Salaam* crossed its path in the Arabian Sea. This vessel, bound from the Mauritius to Bombay, first experienced the effect of the storm by the N.W. wind increasing in force, and meeting a "chopping sea" whilst steering N. by E. As she sailed onwards, the swell of the sea increased, and the wind veered from W. by N. to S.W. and to S.E. The *Futtay Salaam* was laid-to "with the wind at south-east, blowing a furious hurricane, with a tremendous high sea." Colonel Reid observes that, "by steering the ship more to the eastward, more moderate weather and a still fair wind for Bombay would have been obtained."

The second example is from Mr Thom's "Inquiry into the Nature and Course of Storms in the Indian Ocean," a work in which he has ascertained and illustrated in a more satisfactory manner the truth of the theory of storms in accordance with the views of Mr Redfield and Colonel Reid.[2] Mr Thom preserved accounts of the progress of fourteen vessels throughout the storm, nearly all of which were involved in its vortex. The diagram shows the position of the ship *Katherine Stuart Forbes* to the east of the hurricane's course on the 24th March, where no bad weather having been experienced, it is inferred that the storm originated to the westward of her position. Besides this vessel, the tracks of five others are laid down, to show in what manner they sailed into danger. In order to explain this, it must be observed that from the 24th March to the 4th April the westward progress of the hurricane was faster than that of the ships, so that some of them were overtaken by it; but after the 4th April, when the storm began to re-curve, its daily rate of progress was much diminished, and hence some of those vessels which the storm had passed over before, by making sail, overtook it again, and became involved in its vortex. The *Katherine Stuart Forbes*, in steering for the Cape of Good Hope, sailed for twelve days parallel to the storm, and close upon its edge, where she met with a heavy swell, and occasionally severe squalls. From the 1st to the 6th April the ship was sufficiently distant from the edge of the storm to secure fine weather; but owing to its more southerly course, the storm was now approaching the track of the vessel, and she entered that confused cross sea which is always raised by a hurricane. On the 8th, 9th, and 10th, she is described as rolling awfully, with studding-sails, royals, and top-gallant sails all taken in. This hurricane was first discovered in long. 86° E., lat. 10° S., and was finally lost sight of in long. 58° E., lat. 26° S. It thus travelled along the usual hurricane route in fifteen or sixteen days. Its daily rate of progress is computed at about 220 or 230 miles during its early stages, diminishing till, on nearing the tropic, it was little more than 50 miles. This affords a striking example of the dangerous position of ships when meeting re-curving storms about the parallel of latitude 25° or 30°. As shown on the diagram, the five other ships all sailed into the hurricane on the opposite side, which being that next the equator, they had westerly winds at first. Colonel Reid says, that "had these ships been placed upon the *port tack* (being in the southern hemisphere), they would have sailed from the centre of the storm; but their commanders at the time were not aware of the nature of progressive revolving hurricanes."

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[1] The Progress of the Law of Storms. 1849. P. 70.

[2] Inquiry, &c., p. 19. Reid's Progress of the Law of Storms, p. 217.

THE CULLODEN STORM. *(See Diagram No. 5 at the foot of the Plate.)*—Colonel Reid has given a most satisfactory description of this hurricane in his "attempt to develop the law of storms." As the original is too long for insertion here, we shall merely give a summary, extracted from an able article on this subject in the "Edinburgh Review," vol. lxviii., p. 427, by Sir David Brewster:—

"This storm was experienced in March 1809, by the East India fleet, under the convoy of the *Culloden* line-of-battle ship. Four of the Company's ships, and H.M. brig of war *Harrier*, foundered in this storm; the details of which are peculiarly interesting and pregnant with instruction. At the Court of Inquiry which investigated these losses, most of the commanders speak of two distinct storms; but Colonel Reid's Chart proves that the second storm was only the *second* branch of the parabolic route of the storm, into which the *Huddart* sailed, after crossing the narrow and peaceful area which was interposed between the *two* branches. In this pacific spot, the *William Pitt*, *Harrier*, and *Euphrates*, enjoyed two days of fine weather in consequence of lying to; and a similar advantage was enjoyed by the *Northumberland*, *Indus*, and *Sovereign*, which, by lying to, got out of the violence of the hurricane. The *Sir William Bensley*, on the contrary, and the *St Vincent*, by running a day's sail ahead of the above seven ships, involved themselves in fresh misfortunes; and the former was hence compelled to lie to on the 17th for 21 hours, under bare poles. The *Culloden* and the *Terpsichore* frigate scudded like the *Bensley*, and the four missing Indiamen followed her. The *Culloden* stood on, and got out of the storm on the 18th, while the *Terpsichore*, in consequence of having lain to on the 15th for 16 hours, was longer exposed to danger. The *four* missing ships were all seen on the 15th, and if they had put before the wind, they must have rushed into the heart of the storm and perished."

TYFOONS OR CYCLONES OF THE CHINA SEA.—The region of these storms, as pointed out in the chart, extends from about lat. 10° to 40° N., and from the coast of China to about long. 145° E. Their mean tracks, for the six months from June to November, in which they occur, are, according to Mr Piddington, as follow:—

June, from E. to W.
July, from between N.E. and S.E. by E. to N. westward.
August, from between E. and S. 40° E. to the W. and N. westward.
September, from between N. 60° E. to S. 10° E. to the S. westward, and N. by westward.
October, from between N. 12° E., and S. 45° E., to the S. by westward, and N. westward.
November, from between N.E. and S.E., to the S. westward and N. westward.

They seldom occur oftener than once in three or four years, and their approach seems to be generally indicated by the appearance of the sky and the state of the barometer. In the description of the tyfoon which visited Hong Kong, 21st to 26th July 1841, Commander Hall says:[1] "For some days previously, large black masses of clouds appeared to settle upon the hills on either side; the atmosphere was extremely sultry and oppressive; the most vivid lightning shot incessantly along the dense, threatening clouds, and looked the more brilliant, because the phenomena were always most remarkable at night, while, during the day, the threatening appearances were moderated considerably, and sometimes almost entirely disappeared. The vibrations of the mercury in the barometer were constant and rapid; and although it occasionally rose, still the improvement was only temporary, the storm was therefore confidently predicted, and the more so because none had occurred for several years. Between seven and eight o'clock in the morning, the wind was blowing very hard from the northward, or directly upon the shores of Hong Kong, and continued to increase in heavy squalls hour after hour. Ships were already beginning to drive, and the work of destruction had commenced on every side; the Chinese junks and boats were blown about in all directions, and one of them was seen to founder with all hands on board. The fine basin of Hong Kong was gradually covered with scattered wrecks of the war of elements; planks, spars, broken boats, and human beings clinging hopelessly for succour to every treacherous log, were tossed about on every side; the wind howled, and tore everything away before it, literally sweeping the face of the waters. From half-past ten until two the hurricane was at its highest, the barometer at this time having descended to nearly 28° 50′, according to some, but on board the *Nemesis* it was never lower than 28° 89′. The air was filled with spray and salt, so that it was impossible to see anything that was not almost close at hand; the wind roared and howled fearfully, so that it was impossible to hear a word that was said. Ships were now drifting foul of each other in all directions; masts were being cut away; and, from the strength of the wind, forcing the sea high upon the shore, several ships were driven high and dry. The native Chinese were all distracted, imploring their gods in vain for help. Such an awful scene of destruction and ruin is rarely witnessed, and almost every one was so busy in thinking of his own safety, as to be unable to render assistance to any one else. Hundreds of Chinese were drowned, and occasionally a whole family, children and all, floated past the ships, clinging, in apparent apathy (perhaps under the influence of opium) to the last remnants of their shattered boats, which soon tumbled to pieces, and left them to their fate. Five days afterwards, on the 26th, there was a recurrence of the tyfoon, which the *Nemesis* rode out very easily in the Typa anchorage at Macao; but it was not so severe as the first one, and comparatively little injury was caused by it."

Within the district of the tyfoons, the Philippine Islands are visited by the peculiar storms called by the Spaniards *tempestados*, and by the Indians *vaguios*; during the prevalence of which the wind passes successively through all the points of the compass, constituting dreadful hurricanes, which devastate the fields, uproot the largest trees, overturn houses, and drive the shipping on shore.[2]

LOCAL STORM REGIONS.—The principal regions of storms are, as we have seen, confined to the vicinity of the West India Islands on the north, and the Indian Ocean on the south, of the equator; but, besides these, many less extensive districts on the globe are periodically visited by storms of more or less violence. Among the districts where these are of very frequent occurrence, may be noticed the region of the Gulf Stream in the Atlantic Ocean; the zone of the variable winds between the N.E. and S.E. trade winds; and, in a smaller degree, the narrow zones of calms at the tropics of Cancer and Capricorn, and the vicinity of Cape Horn: while the regions of the trade winds *in the open sea* are remarkably free from storms.

Winds possess qualities in some degree correspondent with the regions whence they proceed; thus, those which come from the deserts of Asia and Africa are characterised by being excessively hot and dry. The best known of these is the *samoom* or *simoom*—the *samiel* of the Turks (from *samma*, hot or poisonous), which, under different names, prevails in many parts of Northern Africa and Arabia. On the coast of Guinea, where it is called *harmattan*, it blows in December, January, and February: it usually occurs three or four times in a year, and continues from one to six, and sometimes even to fifteen days. During its prevalence the sun is obscured, the verdure of plants is changed into a dull blue, birds and animals are agitated and restless, and the skin of the human body becomes dry and inflamed. In Egypt the hot wind is called *khamsin* (fifty), because it continues for about fifty days, from the commencement of the inundation of the Nile in April, till the month of June. The *hot wind* of Australia and Van Diemen Land is a subject of great interest to the meteorologist. Its mean direction is N.W., and its velocity is sometimes that of a regular gale, but its motion is different, appearing sometimes as if produced by a rotation on a set of horizontal axes, and at others as if by a waving motion, when it appears as if blowing in puffs. On the W. side of the dividing range its effect is to raise the temperature of a summer day 40°, while on the E. side, both in New South Wales and Van Diemen Land, it ranges between 25° and 30°. On its approach all the visible moisture of the atmosphere disappears, and rain never falls during its continuance. Its influence on vegetation is extremely injurious, and its effects on the human constitution resemble those produced in Egypt by the simoom; a feverish heat, a determination of blood to the head, and ophthalmia.

Winds analogous to these are observed in Arabia, Syria, and Persia, in the plains of Southern Russia, and in Beloochistan. Similar appearances indeed, and the opposite phenomena of cold winds proceeding from snow-clad mountains, or ice-covered seas, are observed in every locality on the globe; they generally prevail at the period of maximum heat of the day, and seldom in the morning.

The hot winds of Southern Europe, known as the *sirocco* in Italy and Greece, the *solano* in Spain, and the *föhn* in Switzerland, are usually attributed to the *Sahara*; but Kämtz is of opinion that they arise in the plains of Andalucia, or on the rocks of Sicily.

Diagram No. 2, at the foot of the Plate, shows the effect of the rotation of the wind on the barometer and thermometer. The vane is, as Dove has so beautifully demonstrated, the real regulator of the weather. In the temperate zones there is a continual interchange of polar and equatorial currents—*i. e.*, together with the trade winds, the wind turns, in a certain sense, through the directions of the compass—in the northern hemisphere, from north through east, south, and west; and in the southern hemisphere, from south, through east, north, and west. This is the phenomenon which is called by Dove (Gesetz der Drehung) the law of rotation, which is simply founded on the theoretical observation, that currents of air depend on temperature, as is confirmed by all observations. From this it is evident that the changes of the principal meteorological instruments, viz., the barometer thermometer, and hygrometer, are nothing but the faithful expression of the law of rotation; the effects of which law are explained by the arrows in the respective wind-roses or compasses.

TABLE INDICATING THE FORCE OF THE WIND AND THE STATE OF THE WEATHER. Prepared by Admiral Sir FRANCIS BEAUFORT, and ordered by the Admiralty to be adopted by the Royal Navy.

FORCE OF THE WIND.

0	denotes	Calm.		
1	,,	Light Air, ...	just sufficient to give........................	Steerage-way.
2	,,	Light Breeze, ...	with which a well-conditioned man-of-war, under all sail, and clean full, would go in smooth water, from	1 to 2 knots.
3	,,	Gentle Breeze, ...		3 to 4 knots.
4	,,	Moderate Breeze, ...		5 to 6 knots.
5	,,	Fresh Breeze, ...	in which the same ship could just carry close-hauled	Royals, &c., single reefs and topgallant-sails.
6	,,	Strong Breeze, ...		
7	,,	Moderate Gale,......		Double-reefs, jib, &c.
8	,,	Fresh Gale, ...		Triple-reef, courses, &c.
9	,,	Strong Gale, ...		Close-reefs and courses.
10	,,	Whole Gale, ...	with which she would only bear	Close-reefed main-topsail, and reefed foresail.
11	,,	Storm,..................	with which she would be reduced to	Storm-staysails.
12	,,	Hurricane, ...	to which she could show	No canvass.

LETTERS INDICATING THE STATE OF THE WEATHER.

b denotes Blue sky; weather with clear or hazy atmosphere.
c ,, Cloudy; *i. e.* detached opening clouds.
d ,, Drizzling rain.
f ,, Fog—*f* thick fog.
g ,, Gloomy dark weather.
h ,, Hail.
l ,, Lightning.
m ,, Misty or hazy—so as to interrupt the view.
o ,, Overcast; *i. e.* the whole sky covered with one impervious cloud.
p ,, Passing showers.
q ,, Squally.
r ,, Rain; *i. e.*, continuous rain.
s ,, Snow.
t ,, Thunder.
u ,, Ugly threatening appearance in the weather.
v ,, Visibility of distinct objects, whether the sky be cloudy or not.
w ,, Wet dews.
. Under any letter denotes an extraordinary degree.

By the combination of these letters, all the ordinary phenomena of the weather may be recorded with certainty and brevity.

EXAMPLES:—*b c m*—Blue sky, with detached opening clouds, but hazy round the horizon.
g ṿ—Gloomy dark weather, but distant objects remarkably visible.
q p d l ṭ—Very hard squalls, and showers of drizzle, accompanied by lightning, with very heavy thunder.

TRACKS OF NAVIGATION.

The influence of wind in determining the different navigation routes, is exemplified on the chart by the tracks between the principal ports of Europe, Asia, Africa, and America, which, for the sake of greater clearness, are printed in different colours. Striking examples of this influence occur in the Indian Ocean, in the very circuitous route which must be followed by wind-propelled vessels in the passage between Madras and Bombay, during the south-west monsoon; in the South Atlantic, in the long detour by which alone sailing vessels can reach the islands of Ascension or St Helena from the north; and in the Pacific, by the distance of the tracks from the coast of South America. The average time occupied in the voyage, from port to port, is stated in days on the principal routes.

Prevailing winds are designated by a fan-shaped sign, the wide end of which shows the direction towards which the wind blows; and the letters N.S.E.W., N.W.S.W., &c. (North, South, East, West, North-West, South-West, &c.), indicate the same facts in another form.

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[1] Voyage of the Nemesis: London, 1844.

[2] Les Philippines, par J. Mallat, t. i., p. 109; 1846.

HYETOGRAPHIC

OR

RAIN MAP OF THE WORLD.

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INTRODUCTION.

Among hydro-meteors, rain forms the most important climatic element; hence an inquiry into the quantity precipitated in the various parts of the globe, and its distribution among the different seasons, has an important bearing on many departments of physical science.

The life of plants and animals depends as much on moisture as on temperature, and their development is greatly modified by the dryness or humidity of the atmosphere.

Rain is very unequally distributed over the different regions of the globe. It is, in general, most abundant in those latitudes where evaporation takes place most rapidly; yet there are exceptions to this rule. In many parts of the earth it almost never rains, because, as Kämtz remarks, the greatly heated atmosphere does not contain sufficient moisture to admit of precipitation, even during the greatest decrement of temperature.

The rainless districts of the earth comprise extensive regions almost devoid of vegetation, as the great Desert of Sahara, and that of Gobi or Shamo, and the arid shores of Peru. On the contrary, there are regions where it constantly rains, and these are generally in the vicinity of the sea; thus, in the British territory on the western coast of Africa upwards of 300 inches of rain have frequently fallen during one rainy season alone. From the examination of existing observations, the following general laws have been deduced:—

I. Rain is, in general, most abundant at the equator, and the quantity decreases in a direction towards the poles; because heat, which is the origin of vapour, and the cause of rain, decreases in the same direction.

As stated in a note on the map, this decrease occurs in the following order:—

The annual amount of rain under the tropics of the New World is . .	113 inches.	In the temperate zone of the New World (United States), . .	39 inches.
The annual amount of rain under the tropics of the Old World, . .	79.7 „	In the temperate zone of the Old World (Europe), ...	34 „
Within the tropics generally, ...	96 „	Average within the temperate zone, ...	37 „

From the Island of Haiti, in the Antilles, to Uleaborg in Finland, the annual amount of rain decreases from about 150 to 13 inches.

The number of rainy days, on the contrary, increases with the latitude or distance from the equator; so that, in general, the days on which it rains are fewest where the fall of rain is greatest.

II. The amount of rain decreases in general in ascending from low plains to elevated lands. But, on the contrary, it increases in ascending from plains to the slopes of mountains, till it arrives at a maximum point, when it again decreases; and this influence of elevation is so great that, while at Paris the annual fall of rain is 20 inches, the average annual depth on the Mountain of Great St Bernard is 63.13 inches. Steep and rugged mountain chains promote, through partial currents of air, the formation and increase of clouds; hence mountain chains of this form are more cloudy and rainy than those with smooth slopes and uniform summits. The general law of decrease from low to high lands is observed when these consist of table-lands surrounded by border mountains; because the latter present little or no material for the formation of vapour, having already precipitated the passing clouds; hence, table-lands are characterized by great dryness.

Chilan and Mazanderan, two provinces of Persia, on the Caspian Sea, in the low coast-plain at the foot of Mount Elbrus, are distinguished by the great amount of rain with which they are visited; whilst on the table-land of Iran (2,500–3,000 feet high) a cloud is hardly ever known to disturb the serenity of the atmosphere, and the brightest metal exposed to the open air is not rusted.

III. The quantity of rain decreases as we recede from the coasts to the interior of continents; which is occasioned by the greater amount of vapour that arises from the sea than from the land, and because between land and sea there is a greater interchange of heat, and consequently a greater movement in the aërial currents, than between different parts of a continent, especially if it be not mountainous. This rule is apparent in the interior of the United States of North America, in the centre of the plains of the Orinoco, in the steppes of Siberia, and in the interior of Australia (where the air is very dry), as well as in the countries between the tropics. There are, however, many exceptions to this rule, depending on the geographical position of countries in relation to the regions of winds and the directions of the mountain chains. Thus, a mountain chain may be the cause of moisture to one country, and of drought to another in its vicinity—of the former, when the country in question is situated on the side of the mountains against which the rain winds commonly blow; and of the latter, when it is situated on the other side of these mountains.

IV. In the temperate zone of both hemispheres, the western coasts are proportionally more moist than the eastern, because they are exposed to westerly currents of air, which, passing over the ocean, are highly impregnated with moisture. Within the tropics, on the contrary, the eastern coasts, especially those of the New World, are more moist than the western, from their exposure to the trade winds.

V. Seasons of Rain.—In different parts of the earth we recognise certain limits within which it rains more at one season than another.

(1.) We find, north of the rainless district of Africa (latitude 35° north), a district in which it almost never rains in summer; probably because the ascending currents of warm air from the Sahara prevent the formation of rain in the upper strata of the atmosphere. In the other three seasons, on the contrary, the precipitation is very copious, especially in winter. This district, which may therefore be called the *province of the winter rains*, includes the insular groups of Madeira, the northern part of Africa, the southern part of Spain and Portugal, the Island of Sicily, the southern part of Italy, the whole of Greece, and the north-western part of Asia.

(2.) North of this province, the whole of southern and western Europe, belongs to the *province of the autumn rains*; that is to say, in this province, which embraces northern and western Scandinavia, the British Isles, the delta of the Rhine, the western part of France, and all the southern part of Europe south of the Carpathians, the amount of rain which falls in the three autumn months exceeds that of the other three seasons.

(3.) North and east of this district lies the *province of the summer rains*, including the eastern parts of France, the Netherlands, except the Rhine delta, the north of Switzerland, the whole of Germany north of the Alps and Carpathians, Denmark and southern Scandinavia, as well as the whole of central Europe, and the countries beyond the Ural Mountains to the interior of Siberia, where showers are as rare in the winter as they are on the coasts of the Mediterranean in the summer months. At Nertchinsk whole months pass away in winter without a shower falling; and this is the case also at Irkutsk and Yakutsk. From the end of autumn till the month of April not a cloud is to be seen here; and the sun rises as it sets, perfectly serene and bright. In this division of atmospheric precipitation among the different seasons in the temperate zone, we recognise the difference between the maritime and continental climates: in the former the winter and autumn, in the latter the summer, rains prevail.

(4.) The proportions of rain in the different seasons on the eastern coast of the Old World cannot be specified, for want of a sufficient number of observations; but on the western coasts of the New World we find that the Aleutian Isles, which are on the same parallel as the north of Germany, have fixed winter rains; at Oonalashka there are seasons in which rain has been observed to fall during the whole winter. On the north-west coast of America there seems to be no fixed season of rain. The Island of Sitka, which is in the same parallel as the north point of Jütiand, had, in the year 1828, no fewer than one hundred and twenty days of uninterrupted rain or snow, and only sixty-six days which could be said to be perfectly fair; indeed, there have been years in which only forty dry days have been observed. This almost incessant precipitation on the north-west coast appears to be changed into a winter rain in the interior of North America; and this again merges into the summer rain which prevails on the eastern coasts of the United States.

(5.) In the Southern Hemisphere, in Chile and the south-western part of America, winter is the rainy season, whilst on the eastern side of the Cordilleras the rains occur in summer; but farther south, in Tierra del Fuego and the extreme point of the continent, the two provinces meet—the periodical precipitation disappears, and it rains and snows throughout the year with a violence resembling the torrents of the tropics. At Cape Horn, a quantity of rain was collected in forty-one days, which measured the astonishing depth of 153.75 inches. This excessive fall of rain occurs along the whole western shores of Patagonia, from Magalhaen Strait to Cape Tres Montes; a condition which is favoured by the height and ruggedness of the coasts, and the incessant westerly winds, which carry the vapour collected from the ocean to be here precipitated in the form of rain.

(6.) Southern Africa, and Australia beyond the tropics, suffer from great droughts, which, in the latter case, is periodical, and, as far as can be yet ascertained, recurs in the countries of the eastern coasts in a period of about twelve years, and sometimes continues for three years, during which time very little, indeed almost no rain falls. In other respects, however, the regions of Southern Africa and Australia resemble each other in their rainy seasons, which, in both, occur during the autumn and winter months.

(7.) The next consideration is the frequency of the fall of rain in different parts of the earth. When the yearly amount of rain falls in numerous small quantities, its effect on climate is very different from that produced by few and heavy showers. The annual amount of rain at the equator is 96 inches, and this falls in seventy-eight or eighty days, averaging about 1.14 inch daily; while at St Petersburg the annual amount is 17 inches, which falls in one hundred and sixty-nine days, averaging for each rainy day, little more than 0.1 inch. This position will be more fully exemplified in the notes to the Rain Map of Europe.

DESCRIPTION OF THE MAP.

The statistics of the amount of rain which falls in extra European countries are too few, and the stations at which they have been made are too much isolated, to admit of anything more, in this first attempt to construct a Rain Map of the World, than the most general indications. The carefully registered observations of many years will be necessary, before we can venture to draw on the chart of the world curves of equal quantities of rain similar to those delineated on the Map of Europe, which forms the next sheet of this division.

The principle adopted in the construction of this map is that of light and shadow—the light spaces on the map indicate the total absence, or great paucity of rain, and the shaded parts indicate an amount of rain proportioned to the depth of shadow. The darker the shading, therefore, so much greater is the amount of rain. The space within the tropics, with some exceptions, is the darkest, and the shading is, in general, lighter (not reckoning the rainless districts) the farther we recede from the equator.

I.—ZONE OF THE PERIODICAL RAINS.

Coloured ORANGE TINT *on the Map.*

Within the tropics, one half of the year is characterized by extreme moisture, and the other by drought. The rainy season follows the apparent course of the sun. On the north of the equator the period of rain prevails as long as the sun has northern declination; on the south side of the equator, the rainy season begins as soon as the sun has passed into the Southern Hemisphere. Generally the rainy season occurs to a given place under the tropics when the sun forms the smallest angle with its zenith.

In countries situated between 5° and 10° of latitude north and south, where there is a longer interval between the periods of the passage of the zenith, there are two rainy and two dry seasons. The greatest of these lasts three or four months, and occurs at the time when the sun passes over the zenith, in its progress to the nearest tropic. The other occurs when the sun approaches the parallel of the place, on its return from the nearest tropic, when the rains are much less copious, and last only from six weeks to two months; towards the tropics these merge into the regular rainy seasons. The quantity of water which falls between the tropics in a month is greater than that of a whole year in Europe; but the rain does not fall, as is erroneously supposed, for continuous days without interruption; indeed a day of uninterrupted rain is more rare in tropical countries than in Europe. Notwithstanding local causes, the phenomena succeed each other with great regularity. The sun rises generally in a clear sky; clouds appear two hours before noon, and at noon the rains set in, frequently pouring in torrents for four or five hours; but at sunset the clouds quickly disappear, the rains cease, and not a drop falls during the night. At the commencement of the rainy season the low countries are frequently covered with water to a depth of ten or twelve inches, which loads the atmosphere with vapours, and causes those exhalations so detrimental to health. In the open sea, within the zone of the trade or passage winds, it never, or at least very seldom rains; but the narrow zone between the trade winds, characterized by variable winds in the Atlantic and Pacific Oceans,[1] is the scene of very frequent, indeed an almost constant, falling of rain, accompanied by electric explosions. The countries within this zone appear never to be many days together without rain; and the rainy season is here only distinguished from other seasons by the more constant and more abundant fall of rain.

India offers a remarkable exception to this order of the seasons—the rainy and dry season not being there regulated by the position of the sun, but by the direction of the monsoons and the position of the coast lands. The western coasts are watered by the south-west monsoon, which prevails from April to October, and the eastern by the north-east monsoon, from October to February.

These circumstances prevail over all the countries of the Indian Sea—on the one side to Madagascar and the eastern coast of Africa, and on the other to the northern district of Australia. When the wind, blowing from the south-west, is forced to ascend the slopes of the Ghauts, the vapours condense on their summits, and violent storms occur almost daily. The greatest amount of rain falls in the month of July. During the south-west monsoon it seldom rains in the interior, and the sky is serene on the eastern coasts.

The same circumstances take place on the coast of Coromandel during the north-east monsoon, but as the mountains are less steep, the rains are not so abundant; while it continues to rain on the east coast, the western coast enjoys a clear and unclouded sky. Some places in the middle of the peninsula have partial rains throughout the year, whilst the table-land of the Deccan participates in the climate of both coasts.

The influence of the monsoons reaches to the border of the Himalaya Mountains, and far into the interior of China, so that even Corea is included in this district. In the western regions of these interior countries, in Upper India and Western China, the rainy season prevails during the south-west, and in Eastern China, during the north-east monsoon. In the Southern Hemisphere the rainy season corresponds with the south-west monsoon, whilst the south-east monsoon forms the dry season. In Africa the periodical rains do not reach the Tropic of Cancer, their limits being found on the southern border of the Sahara, and in the middle of Nubia, about 16° north latitude. Near the equator the rainy season commences in April. Between latitude 10° north and the Tropic of Cancer, especially in the countries watered by the Senegal, it lasts from the beginning of June to November. In the New World, the tropic itself forms the limit of the periodical rains; yet a great part of the western coast of tropical America, the Peruvian coast, is seldom or never visited by rain, because the rain clouds discharge themselves on the eastern side of the high chain of the Andes.

At Panama, the rainy season commences early in March; while at San Blas, in California, it seldom begins till the middle of June. The coasts of Chile and Patagonia are visited by heavy winter rains; while the eastern coast, from the Tropic of Capricorn to Tierra del Fuego, has only light rains in summer.

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[1] Along the polar borders of the calm belts of the tropics there are other regions of precipitation, but the rains there are not so constant as in the belt of equatorial calms.

II.—ZONES OF CONSTANT PRECIPITATION.

In the regions beyond the tropics, the periodical rains disappear, and are succeeded by the rains which occur throughout the whole year. We have designated the extra-tropical regions "zones of constant precipitation," to distinguish them from the regions of the periodical rains: in the former it does or may rain during every day of the year, and the rains are probably as common during the night as in the day; whereas in the latter, during many months, not a drop of rain falls, and even in the rainy season the nights are perfectly dry. Between the tropics, the greatest quantity of rain falls when the sun is at the zenith, or in the season corresponding to our summer, while north of the tropics the greatest amount falls in winter. Designating the annual amount of precipitation by 100, we find the relative quantities of rain, in the different seasons of the year, as follows:—

	Per Cent.
Winter,	50.6
Spring	16.3
Summer,	2.8
Autumn,	30.3

The same relative quantities are found on the north-west coast of Africa and the Canary Isles. This remarkable contrast between the seasons is a sudden, not a gradual transition, as may at first be imagined. "I insist on this fact," says Kämtz, "to show how completely it is at variance with the assertion hazarded by the old meteorologists." The cause of this sudden change may frequently be recognised in the mixture of a volume of air of different temperatures—variable winds often occasioning this mixture. In summer, the regular east winds extend to the coast of Portugal;[1] this produces less disturbance in the equilibrium of the atmosphere, and consequently clouds are more rarely formed than during the variable winds of winter.

III.—RAINLESS DISTRICTS.

The immense tracts marked "Rainless Districts" on the map extend on both sides of the equator; near the tropics, they form a belt round the globe, interrupted only by mountain ranges. In some of these districts a drop of rain is never known to fall; and in others, it is known only at long intervals, and in very small quantities.

The most extensive of these districts is that which stretches from the borders of Marocco eastward through the desert of Africa, the low coasts of Arabia, Iran or Persia, and the desert province of Meekran in Beloochistan, occupying a space of 80° of longitude by 17° of latitude, or about four millions of square miles.

The next comprises the great Desert of Shamo or Gobi, the table-land of Tibet, and part of Mongolia—an extent which we may estimate at about two millions of square miles; and the third, comprising different portions of America, may be reckoned at about half a million of square miles.

In the New World, the rainless district on the north of the equator embraces the table-land of Mexico, and a part of Guatimala and California. On the south of the equator it extends along the western declivity of the Andes of Peru, towards the Pacific Ocean. The absence of rain in this tract is accounted for from the circumstance that the clouds, driven by the passage winds, discharge themselves on the eastern declivities of the Cordilleras. From the total want of rain, and the entire absence of electrical explosions, the inhabitants of the coast, in spite of the garrua,[2] boastingly speak of "la serenidad perpetua del Peru" (the perpetual serenity of Peru).

The inhabitants of Lower Peru see lightning on the distant sides of the Cordilleras; but they are as little acquainted with the roll of thunder as are the inhabitants of Greenland.[3]

From the light style of building their houses, the Peruvians would feel the effects of rain more than that of an earthquake; when such a phenomenon is so rare on the coasts that it appears scarcely two or three times in a century, it may well be supposed capable of alarming the careless inhabitants of the tropics.

Great destruction was caused by the fall of rain in Lower Peru in the years 1701, 1720 (January), and especially in 1728 (February and March), when rain fell, almost without interruption, for forty days in the plains at the foot of the Cordilleras, and even on the coasts. The rain was accompanied by thunder, and occasioned epidemics among the people of the country.

In the year 1790, in the little town of Lambayeque, at the northern part of the Wilderness of Peru, several houses fell during a shower of rain of a few hours' continuance: these, however, were built so lightly as more to resemble the card-houses of children than dwelling-places for social use; such anomalies, which have also been remarked in the delta of Egypt and at Cairo, throw important light on the extraordinary meteorology of Lower Peru.

It would be interesting accurately to ascertain the total amount of rain which is precipitated by the atmosphere over the whole world in the course of a year. The following calculation gives the approximate result as nearly as our present amount of knowledge on the subject will permit:—

Within the tropics the mean annual fall of rain is about 8.50 feet, in the temperate zones 3.05 ft., and in the frigid zones 1.25 ft. But the *area* of the torrid zone may be represented by 4 nearly; that of the sum of the two temperate zones by 5, and that of the two frigid zones by 1. Now, proportioning the fall to these numbers representing the respective surfaces, the general mean for the whole earth will be five feet of depth of fall, very nearly. This mean depth would give one hundred and eighty-six thousand two hundred and forty cubic imperial miles of water, or seven hundred and sixty billions, or, as this is sometimes expressed, seven hundred and sixty millions of millions of tuns of water for the total annual fall of rain on the surface of the globe; which result is considerably strengthened by the experiments of the celebrated Dr Halley on evaporation.

All existing observations have been collected and brought into one view in the following table. The figures express, in detail, what the map represents, horizontally by means of shading, and perpendicularly by the assistance of the diagrams at the foot of the sheet.

IV.—LIMITS OF THE FALL OF SNOW.

At the level of the sea between the tropics, and even far beyond them, precipitation in the form of snow is unknown. In the western part of the Old World, the equatorial limit of the fall of snow nearly coincides with the parallel of 30° north latitude, so that it includes the whole of Europe.

In the New World it follows nearly the same line, extending through the southern part of the United States. In the Southern Hemisphere, the equatorial limit of the fall of snow appears to correspond with the parallel of 48° south. Snow, as might be expected, increases in a northerly direction; but it also increases in the direction from west to east—the farther we proceed from the Atlantic Ocean, so much more abundant is the fall of snow. This subject will be more fully explained in the notes to the Rain Map of Europe.

I. YEARLY AMOUNT OF RAIN WITHIN THE TROPICS.

1. OLD WORLD.

Place of Observation.	Latitude.	Rain, inches.
Pulo Penang, South-east Peninsula,	5° 25′ N.	100.5
Province Wellesley,	5 25	78.8
Ceylon,	6 57	91.7
Mean of Peninsula of Hindostan,	8° to 32°	117.5
Christiansborg, Guinea,	5° 30′	19.2
Sierra Leone, Guinea,	8 30	189.6
Gondar, Abyssinia,	12 36′	37.3
Port Louis, Mauritius,	20 10 S.	35.2
Macao, China,	22 11 N.	68.3
Canton,	23 6 N.	69.2
Mean,		79.7

2. NEW WORLD.

Place of Observation.	Latitude.	Amount in English inches.
San Luis de Maranhao, Brazil,	2° 31′ S.	280.00
Cayenne, Guiana,	4 56 N.	116.27
Paramaribo, Guiana,	5 40	229.20
Demerara, Guiana,	6 45	156.71
Cumana, Venezuela,	10 27	7.62
Trinidad,	10 40	62.92
Curaçao,	12 15	26.64
Grenada, Little Antilles,	12 15	103.41
Barbadoes, Little Antilles,	13 05	57.58
Kingston, St Vincent, Little Antilles,	13 10	82.07
St Vincent, 9 miles east of Kingston,	13 10	67.13
Guadeloupe, { Basseterre,	16 05	126.85
Guadeloupe, { Matouba,	..	292.03
Antigua, Little Antilles,	17 03	39.49
Jamaica, mean of the whole Island,	18 00	70.00
St Bernarda, Tortola Virgin Isles, 920 ft. high,	18 20	65.06
Tivoli, Haiti,	19 00	106.08
Vera Cruz, east coast of Mexico,	19 11	66.09
Cape Haytien, Hayti, or San Domingo,	19 43	127.88
Rio Janeiro, Brazil,	22 54 S.	58.68
Havana, Cuba,	23 09 N.	90.66

Probable mean value of all places of observation, 113 inches.

Mean Yearly Amount under the Tropics, Old and New World taken together, 96 inches.

II. YEARLY AMOUNT OF RAIN IN THE TEMPERATE ZONE.

1. EUROPE.

District or Country.	Yearly Amount of Rain, in Eng. inches.	Divisions in the different seasons. Per-centage of Rain in			
		Winter.	Spring.	Summer.	Autumn.
Madeira,	29.82	48	17	4	31
South-west coast of the Spanish Peninsula,	30.07	32	29	4	35
Sicily,	23.55	50	25	4	21
West side of the Apennines,	35.17	27	23	12	38
East side of the Apennines,	26.70	26	25	17	32
South declivity of the Northern Apennines,	63.96	27	23	13	37
Transpadanic Plain,	25.61	26	24	16	34
Cispadanic Plain,	36.25	21	23	25	31
South declivity of the Alps,	57.57	20	22	26	32
North side of the Alps,	35.27	19	20	35	26
West declivity of the Alps,	46.92	20	24	16	40
Valley of the Rhone,	36.18	20	23	20	37
South France,	23.54	25	23	13	39
West France,	24.61	26	21	22	31
North France and Belgium,	22.47	21	24	29	26
Middle Rhine Valley,	25.63	19	24	31	26
South Germany,	26.64	18	21	37	24
Hungarian Plains,	17.05	19	25	26	30
Middle and North Germany,	20.35	20	23	37	20
Netherlands,	26.70	20	18	30	32
British Islands, Plains,	27.09	23	20	27	30
British Islands, Mountain Ranges,	50.00	26	19	25	30
South Scandinavia and West Russia,	21.33	19	17	33	31
West Coast of Scandinavia,	82.12	26	18	21	35

Mean quantity of rain in Europe between 36° and 60° north latitude, 24 inches.

Maximum,	Coimbra, in Portugal, mean of two years' observations,	224 inches.
	Tolmezzo, in the Southern Alps, mean of twenty-two years' observations,	95 "
	Bergen, in Norway, ten years' observations,	82 "
Minimum,	Iekaterinburg,	13 "
	Madrid—Table-land in New Castile,	9 "

2. AMERICA.

Places and Districts.	Latitude.	Amount of Rain, in Eng. inches.
Key West, in Florida,	24° 33′ N	35.56
Charlestown, in South Carolina,	32 41	47.60
Washington, Capital of the United States,	38 53	26.30
Marietta, in the State of Ohio,	39 25	34.16
West Chester, in Philadelphia,	39 58	46.89
Providence, in Rhode Island,	41 49	41.64
Cambridge, in Massachusetts,	42 23	38.42
Burlington, in Vermont,	44 28	29.44
East Port, in Maine,	44 54	36.28
New York, mean of four years' observation in 32 places,	40 42	36.28

Mean quantity of rain in the United States of North America, between 24° 30′ and 45° north latitude, ... 39 inches.

3. AUSTRALIA.

Places and Districts.	Yearly Amount of Rain, in Eng. inches.	Divisions in the different Seasons. Per-centage of Rain in			
		Winter.	Spring.	Summer.	Autumn.
Paramatta, New South Wales,	28.78	6	14	38	42
Sydney, New South Wales,	26.68	18	23	24	35
Mean of Ports Macquarrie, Jackson, and Philip,	48.69	..	..	..	..
Hobart-Town, Van Diemen's Land,	22.42	32	25	25	18
Albany,	32.06	60	20	3	17
South Australia,	23.43	..	..	..	..
New Zealand,	52.19	..	..	..	..

Mean, 33 inches.

Average value of the amount of rain.

Within the tropics,	96 inches.
In the temperate zone of the Northern Hemisphere,	37 "
In the temperate zone of the Southern Hemisphere,	33 "

EXPLANATION OF THE RAIN-MAP OF INDIA.

The rain-fall of India is regulated, as stated above, by the periodical return of the monsoons. Soon after the vernal equinox, the north-east trade-wind begins to veer more towards the east and south. In March and April it has a south-easterly direction at Madras and along the south-eastern apex of the Peninsula; and, generally speaking, during May, June, July, August, September, and part of October, the south-west monsoon blows over India. The elevated ridge of the Western Ghauts intercepts the moisture of the south-west monsoons. The mean annual fall of seven stations on the Malabar coast is 81.7 inches, while 254 inches fall at Mahabuleshwar; and the mean of six stations on the Ghauts, at elevations of 150 to 4500 feet, is 175.2 inches annually. The deposition diminishes very abruptly on the eastern slopes, so that the mean annual fall on the table-land of the Deccan does not exceed 25 to 36 inches.

The south-west monsoon, assuming generally a more southerly direction in the meridian of Calcutta, passes upwards to the Himalayan range. From 60 to 80 and 170 inches of rain are deposited along the shores of the Bengal coast, while 610 inches fall at the elevated station of Cherrapongi.[4] The high ranges of the Himalaya, stretching north-westward, form a vast screen, which completely intercepts and condenses, in the form of rain and snow, almost every particle of the remaining moisture carried along by the winds of the Indian Ocean; and hence this region forms the main sources of the great rivers of Hindostan. The central parts of Bengal are but moderately supplied with moisture, and the district of Scinde is almost a rainless one.

From October to February the north-east monsoon prevails. This is essentially a dry wind, but it acts as a condenser of the moist vapours of the Coromandel coast. The annual fall of rain on this coast varies from 51 to 28 and 24 inches. Uttray Mullay, situated at the junction of the Eastern and Western Ghauts, and partaking of the influence of both monsoons, has an annual fall of 263 inches.

The maximum fall of rain in one day in the West Ghauts is stated at 13 to 15 inches, and the daily average in June, July, and August, is 12 inches. On the coast, 4, 7, and 9 inches are stated to have fallen within twenty-four hours. Hail-storms are of frequent occurrence in India, and large masses of ice occasionally fall. The hailstones are frequently of the size of pullets', and even goose eggs. Hail-storms on the Malabar coast seldom extend south beyond the 20th parallel of latitude, though, on the Coromandel coast, they are frequent as far south as Madras.

The mean maximum summer temperature is marked on the map at various stations. In the south this maximum occurs in April; in the central and middle regions it occurs in May and June. In the valley of Bengal it amounts to 102°. In the South Peninsula it ranges from 73° to 88°.

Slight fogs occur at Bombay in February and March; and dense fogs are common in the elevations of the West Ghauts. There are no fogs at Madras; and at Calcutta mists occur only occasionally about sunrise.[5]

TABLE OF ANNUAL RAIN-FALL IN HINDOSTAN.

	Stations.	Elevation above sea, in feet.	Lat. N.	Long. E.	Rain, in inches.	Rain-falls.	Months of greatest rain.
Ceylon.	Colombo,	..	6° 57′	80° 0′	89.0	April to September	.. .. ..
	Kandy,	1676	7 18	80 50	84.0	Do.	.. .. ..
Malabar Coast.	Cape Comorin,	50	8 4	77 30	28.3	March to January	May, June, October, November, Dec.
	Trevandrum,	130	8 9	76 55	64.5	Do.	May, June, October
	Quilon,	30	8 53	76 39	76.0	Do.	.. .. ..
	Cochin,	30	10 30	76 20	106.6	March to February	May, June, July, August, October
	Dodabetta,	8640	11 23	75 47	104.0	February to December	Do.
	Uttray Mullay,	4500	11 0	77 0	263.0	March to February	June, July, August, September
	Mercara,	4500	12 26	75 50	143.0	March to November	Do.
	Mahabuleshwar,	4500	17 56	73 30	254.0	May to December	Do.
	Sattara,	2320	17 4	74 2	40.0	Do.	June, July, August
	Poonah,	..	18 30	74 2	19.0	Do.	Do.
	Bombay (during monsoons, 76.8 in.),	Sea coast	18 53	72 48	80.04	June to October	June, July, August, September
	Baroda,	..	22 20	73 0	31.5	Do.	.. .. ..
Scinde.	Hydrabad,	..	25 22	68 22	1 to 8	.. ..	.. .. ..
	Kurrachee,	..	24 20	67 12	0	.. ..	.. .. ..
Coromandel Coast.	Palamcotta,	200	8 30	78 0	21.0	.. ..	May, June, October, November, Dec.
	Vasrioor,	60	8 0	78 0	24.0	.. ..	Do.
	Madras,	Sea coast	13 4	80 14	51.6	May to January	September, October, November, Dec.
	Masulipatam,	do.	16 10	81 14	43.0	Do.	.. .. ..
	Nagpore, Deccan,	..	21 9	79 11	50.2	Do.	.. .. ..
	Beejapore,	..	17 0	75 50	25.0	.. ..	.. .. ..
Bengal.	Calcutta,	18	22 33	88 19	64.0	March to November	June, July, August, September
	Chittagong,	..	22 20	91 47	86.3	April to November	.. .. ..
	Cherrapongi,	4500	25 16	91 43	610.3	February to November	.. .. ..
	Sylhet,	..	24 53	91 50	209.8	Do.	.. .. ..
	Bhaugulpore,	..	25 14	87 0	42.45	June to November	.. .. ..
	Darjeeling,	7500	27 3	88 18	125.2	July to November	.. .. ..
	Moulmein,	Sea coast	16 3	97 68	175.0	June to September	.. .. ..
	Benares,	..	25 18	82 55	41.6	.. ..	.. .. ..
	Allahabad,	..	25 27	81 50	27.8	.. ..	.. .. ..
	Agra,	..	27 10	78 0	20.9	.. ..	July, August, September
	Delhi,	..	28 41	77 5	20.3	.. ..	July, August
	Meerut,	..	29 0	78 0	22.0	.. ..	.. .. ..
	Rohilcund,	..	30 20	78 0	36.0	.. ..	.. .. ..

MEANS OF THE VARIOUS LOCALITIES.

Mean of West or Malabar Coast,	81.7
" West Ghauts,	175.2
" East Coasts,	52.8
" North-east Provinces,	242.1
" Central Bengal and Deccan,	36.0
Mean of the whole Peninsula,	117.5

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[1] At Mafra, the mean direction of the wind is north 3° east, while in winter south winds commonly prevail.

[2] "During a great portion of the year the serene atmosphere loses its transparency, becomes troubled, and is covered by a singular vapour, known to the inhabitants under the name of the *garrud*, *garrons*, or *garruna*." These vapours "are so thick, that the sun seen through them with the naked eye assumes the appearance of the moon's disc. They commence in the morning, and extend over the plains in the form of refreshing fogs, which disappear soon after mid-day, and are followed by heavy dews, which are precipitated during the night."—PROFESSOR FOURNET, *Annales de Chimie et de Physique*, quoted in the *Edinburgh New Philosophical Journal*, January 1845.

[3] As in the tropics (*e.g.*, in the Antilles), so in Caraccas, the fall of hailstones creates astonishment equal to that caused by the fall of aerolites with us; and in Lima the remembrance of the days are kept up in which a peal of thunder was heard, as the 13th July 1652, 8 P.M.; another in 1720, and 1747, and the 19th of April 1803.—HUMBOLDT.

[4] *Reports, British Association*, 1852.

[5] COL. SYKES'S *Meteorology of India*, *Philosophical Transactions*; DR BUIST'S Paper on India, *Report, British Association*.

PLATE 21

HYETOGRAPHIC

OR

RAIN MAP OF EUROPE,

CONSTRUCTED FROM THE HYGROMETRICAL OBSERVATIONS OF THE LAST HUNDRED YEARS.

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I. GENERAL LAWS AFFECTING THE DISTRIBUTION OF RAIN IN EUROPE.

Europe affords many examples of the climatological positions explained in the introductory notes to the preceding chart of this division. These we shall notice in the order therein adopted.

1. The amount of rain decreases as we recede from the equator towards the poles; thus, while under the tropics the yearly average amount of rain is 96 inches, in Italy it is less than one-half, or 45 inches; in England about one-third, or 37 inches; in the north of Germany about one-fourth, or 22½ inches; and at St Petersburg, only one-fifth, or 17 inches.

2. The quantity of rain decreases, in general, in ascending from low plains to elevated table-lands; but this law is reversed in ascending steep and rugged mountain chains. The former case is illustrated by the Iberian Peninsula; for while on the coasts of Spain and Portugal the annual fall of rain amounts to from 25 to 35 inches, on the plateau or table-land of Castile, which is surrounded with mountains, it is only 10 inches. In the latter case, the effect of the Alps is so great, that while the annual amount of rain in the Valley of the Middle Rhine and on the Plateau of Bavaria is only 21 inches, in Berne and Tegernsee, at the foot of the Alps, it is nearly double, or 43 inches.

In England the amount of rain which falls in the mountainous districts is more than double that of the less elevated portions of the country; thus, while the meteorological reports for Essex give only an annual average of 25.6 inches, those for Keswick in Cumberland show no less than 60.5; and at Kinfauns in Scotland, the amount shown on an average of five years, is 31.6, whilst that in the vicinity, on an eminence 600 feet above the level of the sea, amounts to 41.49 inches.

3. The amount of rain decreases in the direction from the coasts to the interior of continents, and this is exemplified by the difference between the coasts of the Atlantic Ocean and the countries of Eastern Russia. The western coasts of Great Britain, France, and Portugal, have an annual average of from 30 to 50 inches, Bergen in Norway has 80, and Coimbra in Portugal 111 inches of rain; while in Central and Eastern Europe, in Moravia, and through Poland and Russia, it falls to 15 inches. At Iekaterinburg on the Ural Mountains it is only 13 inches; and in the interior of Siberia it is still less.

4. In both hemispheres within the temperate zone, the western coasts are proportionally more moist than the eastern. In this quarter of the globe the difference is explained by the prevalence of the westerly winds, which, before arriving in Europe, become charged with vapour in passing over the Atlantic Ocean; whilst those which blow from the east pass over the interior of the continents of Europe and Asia, where the dryness of the air increases so rapidly from west to east, that a mean of seven years' observations gives to Moscow two hundred and five, to Kazan ninety, and to Irkoutsk only fifty-seven days of rain;[1] and the rains which accompany the westerly winds have been observed at Penzance to exceed those caused by the easterly winds, in the ratio of about 3 to 1. The determining causes of the distribution of rain in Europe are thus seen to be the predominance of westerly winds, with the existence of a vast ocean on one side, and a great continent on the other. The former of these causes is thus explained by A. von Humboldt: "The predominating winds of Europe are westerly, which, for the western and central portions of it, are sea winds—currents which have been in contact with a mass of water the temperature of which, at the surface, even in the month of January, does not, at the 45° and 50° of latitude, fall below 51° and 48° Fahrenheit."[2]

5. Observation shows that in different regions of the globe it rains more at one season than at another; now if, in a certain district, during one of the four quarters of the year, a third part of the annual quantity of rain falls, while the remaining two-thirds is either equally or unequally divided over the other three periods, we can make this trisection available as a scale for characterizing the hyetographic condition of the countries, and say the period of the year in which that third falls to the earth is the rainy season of the district under consideration.

Measuring the quantity of rain in Europe by this scale, we find that it is divided into the three following rain provinces:—

1st, The province of the winter rains, comprehending part of the southern portions of Europe;
2d, The province of the autumn rains, comprising the remainder of the southern and the western portions; and,
3d, The province of the summer rains, embracing the whole of the interior of the Continent.

The limits of these provinces are indicated by colours on the map, and the method of their delineation is explained on the next page; but it is obvious that in this, the first attempt to give a survey of the proportions of rain in Europe, these can only be considered as an approximation to the truth. Generally, a strict line of separation can scarcely be possible, where the transition from one province to another is gradual.

II. NUMBER OF RAINY DAYS IN THE COURSE OF A YEAR.

In considering this question, with reference to the countries of Europe, we find, that in the province of the winter rains, and in that part of the province of the autumn rains near the Mediterranean, there are comparatively few rainy days in the year. At the Strait of Gibraltar, the number is sixty-eight, and in the north of Syria fifty-four days. The number increases towards the north. In the south of France it is seventy-six, in the peninsula of the Apennines eighty-nine, in the plains of Lombardy ninety-six, and in Hungary it amounts to one hundred and twelve. The quantity of rain which falls on each rainy day within this whole space amounts, on an average, to 4½ inches, with the exception of Hungary, where it amounts to only 1⅔ inch. In the northern part of the province of the autumn rains, in the vicinity of the Atlantic Ocean, as well as in the interior part of the province of the summer rains, the number of rainy days in a year is very considerable; in general this number is greatest near the sea, and decreases in proportion the farther we penetrate into the interior of the province of the summer rains. On the eastern side of Ireland it rains on two hundred and eight days; in the Netherlands on one hundred and seventy; in England, France, and the north of Germany, and on the Gulf of Finland, on from one hundred and fifty-two to one hundred and fifty-five days; on the plateau of Germany on one hundred and thirty-one; and in Poland on one hundred and fifty-eight days; while on the plains of the Volga at Kazan, it rains on ninety, and in the interior of Siberia, only on sixty days. The amount of precipitation on a rainy day, within the western part of this district is nearly uniform, and varies between 1⅓ and 2⅓ inches. This decrease in the amount of rain, and the number of rainy days in proceeding from the west to the east of Europe and the north of Asia, is owing, as already observed, to the direction of the rain winds, which, in the northern part of the autumn, and the greater part of the summer provinces is westerly. These winds carry the vapours which are accumulated on the Atlantic Ocean to be precipitated over the continent, and as they lose the moisture with which they are charged in traversing the land, the amount of precipitation decreases in proportion as the clouds travel in an easterly direction. Referring to Europe north of the Alps and Pyrenees, M. Kämtz says: If the north-east wind always prevailed it would never rain; for it passes over lands, before arriving at the low latitudes, where the elevation of temperature removes the vapours from the point of condensation. On the contrary, if the south-west wind were to blow incessantly, it would always rain; for as soon as the moist air cools the vapour of water is precipitated.

One point of view, not hitherto sufficiently adverted to, by which we may judge of the proportions of rain, is, the number of days on which rain falls. It appears from the map, that the number of rainy days is greatest in Ireland and in the Netherlands, and that there is a gradual decrease thence, as well in an easterly direction towards the interior of the Continent, as southward to the countries on the coasts of the Mediterranean Sea. In Western Europe, it rains on twice as many days as in Eastern Europe, along the course of the Volga; in Ireland, on three times as many days as in Italy and the south of Spain.

III. NUMBER OF DAYS ON WHICH SNOW FALLS IN EUROPE.

The number of days on which snow falls in Europe increases in the following order from south to north: Palermo has two and a-half snowy days in each winter, Rome one and a-half, Florence one and one-third, Nice under a-half, Venice five and a-half, Milan ten, Paris twelve, Carlsruhe twenty-six, Copenhagen thirty, and St Petersburg one hundred and seventy-one. Meteorological observations are very defective in distinguishing the quantity of water which falls in the form of rain from that which falls in the form of snow, and the same may be said regarding the distinction between the number of rain and snow days. In St Petersburg the quantity of rain, compared to that of snow, is as 1,000 to 384. The first snow falls about the 6th October, and the last about the 17th April.

According to twenty years' observations, it appears that snow may occur in Palermo from December to April. In Florence it occurs even in October, and in Rome it has occurred in April.

In the valleys of Southern Europe, where, as in Rome and Palermo, the mean temperature of the three winter months amounts to 47° and 52°, it is evident that there cannot be either snow or ice of any consequence, or of any long duration, since it must be quickly melted under the influence of the sunbeams.

Nevertheless, during the severe winter of 1812, when Napoleon's army was destroyed in the snow fields of Russia, the sheet of water in the Villa Borghese was so strongly frozen, that the Romans were enabled to enjoy the rare pleasure of skating for several days together. In the Campagna di Roma, as has been said, snow very seldom falls; when that does happen, however, the country people fly into the city, as before the plague, and the Government distributes provisions amongst them. Snow is still more rare in the Pontine Marshes; while the Monte Cavo, the Soracte, the Gennaro, and Coruma, which have a mean elevation of 2,344 to 3,197 feet, remain long visible from Rome, covered with snow. On the high chain of the Apennines, the snow lies longer; and in the beginning of February 1839, the passage between Matilica and Fossato, over the ice-covered road, was not without danger. The snow on the Terminillo Grande, in latitude 42° 30′, first melts in the month of June. The equatorial limit of the fall of snow is indicated on the map. The whole continent of Europe lies, according to this, within the snow line. However, this limit is only to be considered as an approximation. At Lisbon, in the vicinity of this line, there were, during fifteen years, four winters in which it snowed (1806, 1811, 1814, 1815); on the coast of Algarve, this phenomenon is almost unknown.[3] Before 1756, it was said that snow had never been seen in Sevilla; in that year, however, the whole neighbourhood was covered with it.[4] In Gibraltar, snow is rare; and ice is never seen thicker than a Spanish dollar.[5] Malta is never visited by snow flakes. Among the Cyclades snow seldom falls, except in the mountains, and ice is almost unknown. In Crete snow never falls in the plains, and it very seldom freezes.

IV. RAIN WINDS IN EUROPE.

It is an important point in hyetographic inquiries, to ascertain the direction of the prevailing winds which usually bring rain. These, in so far as they are yet known, are represented by arrows on the map. In Western Europe, as well as in the interior of the Continent to near Moscow, the south-western currents of air form the rain-wind; that is to say, it rains most frequently during that wind, and most rarely during the opposite or north-east wind. In the north of Europe, the very opposite is found to be the case, for there the north-east is the rainy wind; and on the southern border of the Spanish Peninsula, the heaviest winter rains occur during the south-west winds.

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[1] Bulletin de la Soc. de Moscow 1837, No. iv., p. 52.—*Humboldt, Asie Centrale*, iii., p. 99.

[2] Asie Centrale, tom. iii., p. 29.

[3] Balbi, Essai Statistique, du Royaume de Portugal, tom. i., p. 97.

[4] Lampadius, Systematischer Grundriss der Atmosphärologie, s. 279.

[5] Montgomery Martin, British Colonies, vol. v., p. 60.

DISTRIBUTION OF RAIN IN EUROPE.—EXPLANATION OF THE MAP.

The accompanying map is an attempt graphically to represent the proportions of rain in Europe. Rain falls in drops varying in size from about one-twenty-fifth to one-third of an inch, and the quantity is measured by the depth which falls on the surface of a square foot, determined by inches and parts. The map is constructed on the scale of French inches,* fifteen of which are equal to sixteen English inches, nearly. In the following remarks the English equivalent of the French figures is given in footnotes below. The principle on which this map is constructed is the same as that adopted for the Rain Map of the World—that is to say, the amount of rain is indicated by shading, which is darker in proportion as the quantity is greater; but besides the comparative amount of rain in the different countries, this map shows, by means of curved lines, the amount of rain in the different seasons, and the annual per centage of summer rain in Europe. The points which have equal quantities of rain are united by interrupted lines, on the physico-graphic principle, adopted by A. von Humboldt to represent the distribution of heat. These lines may be denominated isohyetoses (or lines of equal rain-fall); they constitute a series of curves, which express an amount of rain increasing from 10 to 100 inches, a curve being added for every 5 inches of additional quantity. These isohyetoses limit certain regions, the shading of which is darker in proportion as the quantity of rain is greater. We find from the map that the darkest places, or those on which the greatest quantity of rain falls, are situated on the west coast of Great Britain and Ireland, the coast of Scandinavia, the Eastern Alps, and in the centre of Portugal. The shading of the countries is lighter in proportion as they recede from the coasts and the mountains, on the principle explained in the introductory notes.

1. PROPORTIONS OF RAIN.—If we assume the yearly quantity of rain as unity, or suppose it = 100, then the atmospheric water falling in every period of the year will form aliquot parts or per centages of the annual amount.

These proportions may be graphically constructed, as is done in the case of the summer rains in our map, so that the quantity is rendered perceptible by means of curves called isotherombroses (or lines of equal summer rain), which show the amount from 0 to 50 per cent. of annual rains, and in an ascending scale from 5 to 50 per cent.

The curve or isotherombrose of 0—that is, the line in the vicinity of which it never rains in summer—passes through the eastern part of the Mediterranean Sea, as well as through Syria, and does not touch Europe. The curve or isotherombrose of 5 per cent. annual quantity of rain, first touches our quarter of the earth, still only in a small portion of its southern countries, namely, to the north of Greece, the south of Italy, the south-western section of Spain, and the southern half of Portugal. If we follow the course of these isotherombroses further, we find that they run pretty nearly parallel with the general contour of the coast of Europe, so that the curve of 20 per cent. of summer rain will be found as well in the north of Europe—on the Scandinavian coast—as in Dalmatia in the south. The curve of 15 inches yearly quantity of rain lies entirely in the interior of the Continent: and this seems to be the medium amount of atmospheric precipitation in the whole of Eastern Europe; for, on the borders of Asia, at Slatoust and Iekaterinburg, in the Ural Mountains, the annual amount of rain probably does not exceed 14.2[1] and 12.10;[2] and the curve or isohyetose of 10 inches lies, it is conjectured, beyond Tobolsk, while it cuts the course of the River Irtish somewhere about 72° east longitude.

The isohyetoses, or curves from 20 to 35 inches medium quantity of rain, which touch upon Great Britain and Ireland, as well as the Netherlands and the west coast of France, are, in so far as their continuation in the Atlantic Ocean is concerned, naturally to be considered as conjectural; and this prolongation, therefore, is only given to represent the probable connection of the phenomena.

The isotherombroses of 45 and 50 per cent. appear on the limits of Asia—the former cuts the Ural Mountains, at Slatoust; the latter at Iekaterinburg.

These last named determinations are, however, only to be considered as an approximation to the truth; because they rest on a single year's observations, although they are corrected by the mean of many years' corresponding observations in St Petersburg.[3]

2. RAIN PROVINCES.—The province of the *winter rains* is coloured blue on the map. The line of limit between this and the province of the autumn rains touches the east coast of Italy, nearly under latitude 43°—extends thence probably over the crest of the Apennines southwards—leaves these beyond the parallel of Naples, perhaps under latitude 40°—proceeds for a time along the west coast of Calabria—passes north of the coast of Sicily—extends thence to the Island of Sardinia, so as probably to cut it near its southern shores—strikes the Spanish coast probably at the *Cabo de la Nao*, opposite the Island of Iviça, and leaves the Iberian Peninsula between Lisbon and Coimbra. All the countries to the north-west of this line of separation belong to the province of the autumn rains, and all south to that of the winter rains. The province of the *autumn rains* is coloured orange tint, and the line of separation between it and the province of the *summer rains* (coloured green), proceeds west from the Carpathian Mountains, to the north of the Alps, through the middle of France, the west of Holland, and by the northern part of the Gulf of Bothnia, through the White Sea to the Arctic Ocean.

3. NUMBER OF DAYS OF RAIN AND SNOW.—The number of days on which it rains in any particular region, and the amount of rain or snow which falls on each rainy day, are indicated by letters and figures on the map. Thus, for example, the signs R. D. 112 in Hungary, indicate that in this country (in the plains, for which alone, and, indeed, only for Buda or Ofen, observations exist) it rains on one hundred and twelve days during the whole year, and that on each of these rainy days the quantity which falls amounts to 0. 14.[4] The quantity of rain which falls on a rainy day is greater in the south than in the north of Europe; in the south of Spain it is twice as great as in England; in Italy, three times as great as in Ireland. In Gibraltar the number of rainy days is only sixty-eight, while the amount of precipitation is forty-three inches; the quantity of rain which falls in it, therefore, exceeds by three times the daily quantity in Ofen and St Petersburg. The number of days on which snow falls in the course of a year is expressed in figures placed after the letter S. Thus at Rome, the sign S. 1½, and at St Petersburg the sign S. 171, indicate that at these two places the average number of days on which snow falls in the year is one and a-half, and one hundred and seventy-one respectively.

4. COMPARATIVE QUANTITY OF RAIN IN DIFFERENT PARTS OF EUROPE.—That portion of Europe in which the greatest quantity of rain falls, is very probably Coimbra and its environs. Coimbra, in the Valley of the Mondego, lies at the western declivity of the Serra Estrella, which is remarkable, as well on account of the height of the mountains (7,500 feet) as for the serrated formation of their summits. Unfortunately, the observations employed for this place embrace a period of only two years (1816–17), so that their mean value cannot warrant any great certainty, in elements which, like the quantity of rain, present such great fluctuations from one year to another; besides, it is uncertain whether they are not disfigured by mis-prints.[5]

If we take them exactly as they are presented to us, they give a quantity of rain equal to 211 inches[6]—an enormous amount, which reminds us of the heaviest torrents of the tropics.

The quantity is divided over the periods of the year as follows: Winter, 23.5;[7] Spring, 20.9¼;[8] Summer, 19.8;[9] Autumn, 147.2½ inches.[10] On account of the uncertainty referred to,[11] Schouw has excluded from the calculation of observations the months of September and October of the above-mentioned years, and thus determines the annual quantity of rain at Coimbra to be 127[12] inches.[13]

Kämtz has gone still further, and, besides these two months, has left out of view the month of November 1817, whereby he brings out a yearly quantity of 111⅓[14] inches.[15]

Notwithstanding its high latitude, the coast of Norway is distinguished by an extraordinary abundance of rain, which, according to observations made at Bergen, amounts to 77½,[16] or even to 83[17] inches.[18] This quantity of rain and snow, immense for a climate situated in 60° north latitude, is caused by the high Scandinavian mountain chains, which prevent the passage of the clouds blown from the Atlantic Ocean; they are, therefore, deposited on the summits of these mountains, and discharge themselves on the western declivities, and into the valleys, throughout the year, but chiefly during autumn and winter. The third region in Europe where most rain falls, is the Valley of the Upper Tagliamento, in the Eastern Alps. Here, at the height of 1,000 feet above the level of the sea, lies the little town of Tolmezzo, where observations on the quantity of rain have been made during a period of twenty-five years. These give a yearly average of 90 inches[19]—in the year 1807 it amounted to 151 4·8 inches[20]—and hence it is not improbable, that in the higher regions of those Alpine districts the mean annual quantity amounts to 100 inches.[21]

5. RAIN WINDS.—The direction of the winds, which usually bring rain, is indicated by arrows on different parts of the map, the head of the arrow marking the point towards which the wind blows.

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* The map of the British Isles is on the scale of English inches.

[1] 15.1 English inches.

[2] 13.7 inches.

[3] Recueil d'Observations Magnétiques et Météorologiques faites dans l'Etendue de l'Empire de Russie. Année 1837. This year gives the amount of summer rain for Slatoust, 35 inches. In Iekaterinburg, 63 per cent. of the yearly amount. The correction is, 13 per cent.

[4] 0.15 inch, or about one-seventh of an English inch.

[5] Balbi, Essai Statisque sur le Royaume de Portugal et d'Algarve, tab. 14, p. 112.

[6] 225 inches.

[7] 25 inches.

[8] 22 inches.

[9] 21.2 inches.

[10] 157 inches.

[11] Balbi also brings forward the supposed circumstance, that the autumn of 1817 was very rainy; but this was not the case, at least the Diary of Lisbon shows no trace of it.

[12] 135.7 inches.

[13] Climat de l'Italie, tom. i., pp. 188, 189.

[14] 119 inches.

[15] Lehrbuch der Meteorologie, bd. 1, s. 432.

[16] 82½ inches.

[17] 88½ inches.

[18] The first account is, according to Schouw's reckoning, Climat de l'Italie, tom. i., pp. 171, 184; the second according to Kämtz, who makes use of some additional observations, Lehrbuch der Meteorol., b. 1, s. 465.

[19] 96 inches.

[20] 161½ inches.

[21] 106½ inches.

TEMPERATURE AND HYDROLOGY OF BRITISH ISLES.

The position of the British Islands, surrounded on all sides by the ocean, with a branch of the Gulf-stream flowing along the western coasts, gives a mean annual temperature equal to, and a winter temperature considerably higher than that of countries on the continent of Europe, placed in corresponding or even lower latitudes.

The mean temperature of the western part of Britain is, in winter, 40° 3′ Fahr.; in summer, 59°. That of the eastern is, in winter, 38° 2′; in summer, 59°; affording a general annual mean of 49°.

The mean of the southern part of England is 51°. The more elevated portions of the interior—especially in the northern parts, and in the central portions of Scotland—would, however, exhibit a mean temperature several degrees below this—45° and 46° being the ascertained averages of several localities; while the isle of Unst, the most northerly point of the British Islands, has a mean annual temperature of 44° 7′. The mean temperature of the hottest month (July) is, in Great Britain, from 60° to 65°. The mean temperature of the sea on the west coast is in winter 41°.

The prevailing winds for two-thirds of the year are from the south-west, west, and north-west. In March, April, and May east and north-east, and occasionally north, winds prevail.

The south and south-west winds are of elevated temperatures, and loaded with moisture; the easterly winds, on the contrary, are chill and dry. The western half of Britain is elevated, and in general mountainous—as in Wales, Westmoreland, Cumberland, and in the south-west, centre, and north and north-west of Scotland. The eastern half of the island, on the contrary, is composed of undulating valleys, which slope gently to the level of the Ocean.

At Inchkeith, Firth of Forth, from an average of 10 years, the wind blows between north-east and south-east for 104 days in the year; between south-west and north-west 197 days; variable 64 days. At Cape Wrath east and north winds blow 120 days; south and west 192, and 53 days variable.

The configuration of the land, in conjunction with the prevalence of the moist Atlantic winds from the south-west, entirely modifies the fall of rain and the distribution of rivers. We accordingly find that the greatest amount of rain falls in the western coasts of Britain and Ireland; and the periods of greatest precipitation are in the autumn and winter months—the least quantity falling in the spring months. Thus, dividing the year into three periods of four months each, beginning the winter period with November, the proportional mean fall of rain at the following places is:—

	Winter.	Spring.	Summer.
Penzance, Cornwall,	17.4 in.	12.2 in.	13.5 in.
London,	8.0	6.7	9.2
York,	9.9	7.3	10.0
Keswick,	19.9	16.0	24.0
Glasgow,	15.5	8.3	9.8

The greatest depth of rain noted to have fallen in twenty-four hours is from 1½ to 2½ inches, and, in 1792, at Kendal, 4½ inches.

Average number of days in the year on which rain falls—at

Edinburgh (Inchkeith),	165	Falmouth,	192
York,	173	Keswick,	208
Stone, Staffordshire,	167	Sandwick, Orkney,	203
Southampton,	158	Cape Wrath,	250

On the eastern side of the island the mean annual fall of rain amounts to 27.4 inches; on the west side the mean of the stations is 45.5 inches. As the data for Wales are, however, deficient, and in the other stations there is a preponderance of coast localities, the mean of the whole western region may be fairly estimated at 50 inches, and the mean of the whole of Great Britain at 36 to 40 inches. This includes the regions of greatest deposition. In Westmoreland and Cumberland from 60, 90, to 140 inches fall in several mountainous positions; and, as in the Ghauts in India, the greatest amount of fall takes place at a certain elevation; while above this elevation the amount decreases. The line of maximum deposition in Cumberland is 1900 feet, while on the Ghauts of India it is 4500 feet. It will be seen, from the shadings on the Rain-Map of the British Isles, that the greatest deposition of rain takes place along the tracts of the mountain ranges, and that from these localities also the principal rivers derive their sources. In Ireland the great central plain, and especially its eastern part, receives less rain than the mountainous coasts of the west, south-west, and north.

MEAN ANNUAL TEMPERATURE OF BRITISH ISLES.

EAST SIDE.	Latitude N.	Winter.	Summer.	Year.
Wick,	58° 29	38° 8	55° 3	48° 9
Inverness,	57 28	35 0	57 0	47 7
Elgin,	57 39	38 4	60 4	47 7
Aberdeen,	57 8	39 0	59 5	49 2
Alford (elevation 420 feet),	57 13	35 5	56 4	45 0
Kinfauns, Perth, (elevation 140 feet),	56 23	37 6	57 2	46 9
Dundee,	56 27	41 4	63 4	51 9
St Andrews,	56 19	39 2	58 9	48 6
Leith,	55 59	40 5	58 2	48 3
Edinburgh (elevation 220 feet),	55 57	38 4	57 2	47 0
St Bathans, Berwick (elevation 420 feet),	55 52	36 9	55 1	43 9
Makerstoun,	55 36	38 5	56 7	46 6
York,	53 67	36 2	62 3	49 2
Boston,	52 48	37 7	62 0	49 1
Bedford,	52 8	40 5	62 8	51 6
Oxford,	51 46	37 0	60 3	48 6
London,	51 30	39 5	62 9	50 8
Chichester,	50 5	38 8	60 7	49 5
Mean,		38 2	59 2	48 3
WEST SIDE.				
Unst, Shetland,	60 45	38 6	52 6	44 7
Sandwick, Orkney,	59 5	39 7	54 0	46 5
Glasgow,	55 51	39 6	60 1	49 8
Applegarth, Dumfries (elevation 170 feet),	55 13	36 0	56 1	45 6
Whitehaven,	54 33	39 9	59 6	49 0
Kendal (elevation 130 feet),	51 19	37 0	57 8	47 6
Manchester,	53 29	38 3	59 9	48 8
Liverpool,	53 24	41 3	61 1	50 8
Isle of Man,	54 15	41 7	59 1	49 8
Derby (elevation 160 feet),	52 58	36 3	54 3	41 9
Cheltenham,	51 54	40 6	64 3	51 6
Swansea,	51 36	45 5	60 6	53 7
Bristol,	51 27	40 3	64 3	51 6
Plymouth,	50 22	44 9	60 9	52 0
Penzance,	50 7	44 2	60 9	51 7
Falmouth,	50 9	42 3	58 4	50 2
Mean,		40 3	59 0	49 0
IRELAND.				
Belfast,	54 26	41 4	63 9	52 3
Antrim,	54 43	36 7	58 1	47 7
Dublin,	53 21	39 8	59 6	49 7

MEAN ANNUAL FALL OF RAIN IN BRITISH ISLES.

EAST SIDE; COAST AND INTERIOR.	English Inches.	WEST SIDE; COAST AND INTERIOR.	English Inches.
Sumburg Head, Zetland (elevation 300 feet),	22.7	Sandwick, Orkney,	38
Start Point, Orkney,	27.2	Dunnet Head (elevation 346 feet),	31
Pentland Skerries (elevation 140 feet),	27.1	Cape Wrath (elevation 400 feet),	38.6
Tarbet Ness,	28.2	Stornoway,	35.6
Inverness,	27	Island Glass,	33.3
Elgin,	24	Barra Head (elevation 680 feet),	37.6
Buchan Ness (elevation 175 feet,)	26.5	Lismore Island,	38.7
Aberdeen, Old,	30	Rhinns of Islay,	33.6
" New,	27	Pladda Island,	42.7
Alford (elevation 420 feet),	37	Mull of Cantire (elevation 297 feet),	38.5
Kinfauns, Perth (elevation 140 feet),	31	Rothesay, Bute,	48
Isle of May (elevation 240 feet),	21.7	Castle Toward, Renfrew,	50
Inchkeith (elevation 220 feet),	24.7	Glasgow,	33.6
Edinburgh (elevation 220 feet),	25	Gilmourton, Lanark (elevation 600 feet),	47.2
Glencorse, Peatlands (elevation 734 feet),	36.1	Applegarth, Dumfries (elevation 170 feet),	42.7
St Bathans, Berwickshire (elevation 420 feet),	31	Langholm,	36.7
West Denton, Northumberland,	36.8	Dumfries,	33.5
York,	24	Carsewell, Wigtown,	35.8
Halifax,	27	Mull of Galloway (elevation 325 feet),	25.6
Boston,	23.1	Point of Ayre, Isle of Man,	28.1
Lyndon, Rutlandshire,	24.3	Carlisle,	30
Felthorp, Norfolkshire,	24	Whitehaven,	47.6
Wellingborough, Northamptonshire,	24.8	Keswick (elevation 258 feet),	60
Swaffham Balbeck, Cambridgeshire,	23.8	Grasmere (elevation 180 feet),	107.5
Bedford,	31.7	Styehead (elevation 1290 feet),	92.8
Aylesbury, Bucks,	23.1	Seathwaite,	140.6
Epping, Essex,	26.6	Sparkling Tarn (elevation 1900 feet),	124
London,	24	Kendal,	50
Cobham, Surrey,	24.5	Allenheads (elevation 1300 feet),	47.9
Wingham, Kent,	26.8	Skipton,	34.8
Reading, Berks,	25	Rochdale,	46.7
Hungerford, Berks,	26.5	Liverpool,	34.7
Southampton,	31	Manchester,	37.3
Hastings, Sussex,	31	Stockport,	34.9
Carisbrooke, Isle of Wight,	30.9	Chapel-en-le-Frith, Derby (elevation 1121 feet),	43
		Nottingham,	27
		Derby,	25.7
		Coed Ddu, Flintshire,	38.3
		Swansea,	35.4
		Bath,	32
		Goodamoor, Devon (elevation 360 feet),	56.8
		Penzance, Cornwall,	43
		Pencarrow, Cornwall,	45.3
		Exeter, Devon,	29
		Plymouth,	35.7
Mean of the Stations, East Side,	27.4	Mean of the Stations, West Side,	45.5
IRELAND.			
EAST SIDE.		WEST SIDE.	
Londonderry,	31.1	Westport, Mayo,	46
Donaghadee,	31	Kilrush, Clare,	33
Belfast,	35	Cahirciveen,	59
Killough, Down County,	25	Cork County,	40
Armagh,	32	" City,	36
Dublin,	30.8	Castletownsend,	42
Portarlington, King's County,	23		
Mean,	29.7	Mean,	47.4

NOTE.—Registers of the weather are kept at the stations of the Board of Northern Lights, and the above are from the MS. Reports from 1825 to 1846. The other authorities are, *Edinburgh Philosophical Journal; Philosophical Transactions, London and Edinburgh*; KIRWAN; DALTON; N. Beardmore's *Hydraulic Tables; Reports, British Association*, and private registers.

PLATE 22

ON THE POLARIZATION OF THE ATMOSPHERE.

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INTRODUCTION.

When the light of the sun or of any self-luminous body has been transmitted through certain crystallized substances, or has been reflected from, or refracted by, bodies not metallic, it suffers a physical change, to which the name of *plane polarization* has been given. This physical change consists in decomposing common light into two equal portions of polarized light, one of which is polarized in a plane at right angles to that in which the other is polarized. In doubly refracting crystals, the two pencils are polarized in opposite or rectangular planes; and when common light is reflected from any body not metallic, whether it is solid, or fluid, or gaseous, a portion of the incident light enters the body; and of the portions thus reflected and refracted, precisely the same quantity is polarized—the light polarized by refraction being polarized in a plane at right angles to that which is polarized by reflection.

If the earth had no atmosphere the sky would appear absolutely black; and when the sun sets we should be left in utter darkness. The existence of twilight, however, the blue colour of the sky, and the refraction of the rays which emanate from the stars and planets, place it beyond a doubt that the pure air in which we live and breathe, is capable of acting upon light like all other bodies, and consequently, of producing that physical change which constitutes *polarization*. The polarization of the blue sky, or of the atmosphere, was, therefore, observed and studied by different philosophers, both in France and England; and it was speedily ascertained, in conformity with the laws of polarization, that the polarization was a *minimum* in the vicinity of the sun, where his light is reflected at angles approaching to 90°, or where the incident and reflected rays form an angle approaching to 180°; that it was also a *minimum* in the region opposite the sun, where his light is reflected at an angle approaching to 0°, or at a perpendicular incidence; and that it was a *maximum* in those intermediate parts of the sky, which are distant about 90° from the sun, and where his light is reflected at an angle of about 45°, the polarizing angle for *Air*.

Such was the first view which was naturally taken of the polarization of the atmosphere, and a considerable time elapsed before its leading elements were determined, and its more important phenomena observed and measured. It is to M. Arago, to whom this branch of science owes such deep obligations, that we are indebted for the discovery of the first and leading fact on which the law of atmospheric polarization depends. In examining the region of the sky opposite to the sun, he discovered *a neutral point*, or a point in which there is *no polarization* whatever. This neutral point he found to be 25° or 30° *above* the point diametrically opposite to the sun, or what we may call the *antisolar point;* and we shall distinguish this pole of no-polarization by the name of *M. Arago's neutral point*, or the *antisolar neutral point*. It is best seen after sunset.

In the year 1840, M. Babinet discovered a second neutral point, situated about the same distance above the sun as the neutral point of M. Arago is situated above the antisolar point. This point is most distinctly seen immediately after sunset, but is generally much fainter than the other, owing to the discoloration of the blue sky by the yellow light of the setting sun.

Our readers are no doubt aware, that when light is reflected from the surfaces of transparent bodies, a certain portion of it, and at a particular angle the whole of it, is *polarized* in the plane of reflection, or *positively;* while precisely the same quantity of the transmitted light is *polarized* in a plane at right angles to the plane of reflection or refraction, or *negatively*.[1] Now, in the part of the sky between the neutral point of M. Arago and that of M. Babinet, the light was polarized *positively;* while in the parts of the sky between the first of these neutral points and the antisolar point, or between the second and the sun, it was polarized *negatively*. Hence, it became obvious, that the two neutral points must be produced by a compensation, in which light polarized *negatively* neutralized light polarized *positively*, and that the *negative* light was either produced by *reflection* in a plane at right angles to that passing through the sun, the neutral point, and the observer, or by *refraction* in a plane passing through these three points, or by both these causes combined. But in whatever way the *negative* polarization was produced, it was manifest that the same cause ought to produce a *neutral point beneath the sun*. After many fruitless attempts to discover this neutral point—owing chiefly to the predominance of the sun's light at the part of the sky where it should be found—I at last observed, under a very favourable state of the atmosphere, that the polarization of the sky was *negative* in the space between the risen sun and the horizon. This observation placed it beyond a doubt, that there must be a neutral point below the sun, where that *negative* polarization passed into *positive* polarization; and by concealing the sun from view, and admitting no light to the eye but what came from the probable place of the neutral point, I succeeded in discovering it. After communicating this discovery to M. Babinet,[2] early in 1845, he made several ineffectual attempts to confirm it; and it was not till the 23d July 1846, when the state of the sky was peculiarly favourable for the observation, that he succeeded in obtaining a distinct view of it.[3]

Before proceeding to explain the map of the lines of equal polarization in the pure blue sky, I shall give a brief account of my observations on the three neutral points to which we have referred:—

I.—ON M. ARAGO'S NEUTRAL POINT.

This neutral point is marked P in Fig. 2 of the map. In the normal state of the lines of equal polarization, as shown in the map, namely, when the sun is in the horizon, this neutral point is about 18½° above the horizon or above the antisolar point; but when the sun is about 11° or 12° above the horizon, and the antisolar point of course as much below it, the neutral point is in the horizon, and, consequently, only 11° or 12° above the antisolar point. As the sun descends to the horizon, and the antisolar point rises, the distance of the neutral point from the latter gradually increases; and when the sun reaches the horizon, the neutral point is 18½° above it, and therefore 18½° distant from the antisolar point. After the sun has set, the distance of the neutral point from the antisolar point increases; that is, it rises faster than the sun descends, and its maximum distance when the twilight is very faint, is about 25°.

In the latitude of St. Andrews, M. Arago's neutral point is above the horizon all the day between the middle of November and the end of January. In the other months of the year, it never rises till the sun is within 11° or 12° of the horizon, and never sets till the sun is 11° or 12° above the horizon.

II.—ON A SECONDARY NEUTRAL POINT ACCOMPANYING M. ARAGO'S NEUTRAL POINT.

I observed the first traces of this remarkable phenomenon on the 8th of June, 1841, at 5h 50′, when the positive polarization was strongest close to the horizon, whether land or sea, and to about 1½° above it. Hence, when M. Arago's neutral point rose, it *did not appear first in the horizon*, but about 1½° above it, the compensation taking place where the positive polarization was weaker than in the horizon. When this took place, we had the singular phenomenon of a neutral point *with positive polarization* on each side of it. When this phenomenon was more fully developed, under a favourable state of the horizon, the positive polarization was overcome by the advancing negative polarization. The negative polarization was then immediately below the ascending neutral point; but at a certain distance, a few degrees below the neutral point, the negative polarization was compensated by the excess of positive polarization close to the horizon, and the beautiful phenomenon was seen of two neutral points separated by bands of negative polarization. This phenomenon was best seen on the sea horizon, which was marked by an obscure band a few degrees high, that indicated the existence of a distant haze. On the 21st April, 1842, I observed the secondary neutral point under favourable circumstances. At 6h 22′, when the *primary* neutral point was 15° high, the *secondary* one was 2° 50′ high. At 7h positive bands were still seen above the sea line, and were strongest upon the obscure band above the visible sea line.

III.—ON M. BABINET'S NEUTRAL POINT.

This neutral point, marked P in Figs. 1 and 2 of the map, is situated about 18° 30′ above the sun, when he is rising or setting in a very clear sky. It is not so easily seen as that of M. Arago, and was therefore longer in being discovered. It is above the horizon during the greater part of the year in great latitudes, and being above the sun, it is of course always visible when the sun is above the horizon in a clear sky. When the sun is in the zenith, this neutral point coincides with the sun's centre. As the sun's altitude diminishes, it separates from the sun's centre, its distance gradually increasing till it becomes 18° 30′, when the sun's altitude is nothing, or at sunrise and sunset.

The neutral point of M. Babinet must, like that of M. Arago, be accompanied, in certain states of the horizontal sky, with a secondary neutral point; but I have never had an opportunity of observing M. Babinet's neutral point when it either rose above or set beneath the horizon, which, though not essential, is the most favourable for observing a secondary neutral point.

IV.—ON THE NEUTRAL POINT BELOW THE SUN.

This neutral point is, as we have previously noticed, much more difficult to be seen than that of M. Babinet. In November, December, and January, this neutral point cannot be seen in our latitude, unless when, early in November and late in January, a higher degree of polarization in the sky brings it above the horizon at noon.

As theory indicated the existence of this neutral point, I long sought for it in vain; but when I was assured of its existence by the discovery of negative polarization, which often extended from the sun to the horizon when the sun's altitude was 30°, I took such precautions for excluding all unnecessary light from the eye that I at last observed it near the horizon, with a small portion of positively polarized light beneath it. I afterwards observed it repeatedly when the sun had higher altitudes, and was able to measure its varying distance from that luminary. On the 18th February, 1842, at noon, when the sun's altitude was about 22°, I observed this neutral point in the most distinct manner, the polarized bands being negative below the sun, and positive near the horizon. Its distance from the sun, therefore, was about 15° or 16°. I afterwards obtained the following measures of its distance from the sun:—

	Distance of Neutral Point from the Sun.
1842, February 21, 12h. 39′ . . .	15° 0′
„ April 3, 11 45 . . .	13 0
„ „ 6, 11 6 . . .	12 0
„ „ 8, 2 7 . . .	16 0 estimated.

On the 20th April, in a very fine day, the wind being west and the barometer 30.02, I obtained the following measures:—

	Distance from Sun.
April 20, 12h. 10′ . . .	11° 20′
12 37 . . .	10 40
2 21 . . .	12 0
3 45 . . .	12 35

The maximum polarization of the sky at the time of these observations was equal to a Rotation of 25½°, about 4½° below the greatest maximum.

On the 26th April 1842, when the barometer was at 30.00, and not a cloud in the sky from morning till night,[4] I obtained the following measures:—

	Distance from Sun.
April 26, 11h. 1′ . . .	12° 15′
11 46 . . .	12 30
3 30 . . .	14 35
3 35 . . .	15 5
4 10 . . .	17 45

At 10h 53′, the maximum polarization of the sky, or the Rotation, was 28¾°, and at 11h. 46′, and 3h. 42′, it was 28½°.

On the 27th April, I observed a remarkable series of phenomena relative to this neutral point. The sky was singularly fine—the barometer at 30.04, and at 10h 41′ the maximum polarization of the sky 29¼°, the greatest that I have observed. At 10h 45′, the distance of the neutral point from the sun was 12° 3′, and consequently about 33½° *above* the horizon. At 12h 12′, a fog came rapidly from the sea. The neutral point below the sun was driven beneath the horizon, and Babinet's neutral point rose almost to the zenith. At 1h 20′, the fog diminished. The neutral point below the sun reappeared near the horizon, oscillating up and down, through a space of 5° or 6°, as the fog became alternately denser or rarer.

When the sky is clear, the neutral point below the sun approaches to the sun as his altitude increases, and finally coincides with the sun's centre when he is in the zenith. Hence it follows, that when the sun is in the zenith, the two neutral points in his vicinity meet in the sun, and the system of polarization lines becomes uniaxal.

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[1] These terms are used for the purpose of abbreviation. An account of the Laws of the Polarization of Light by Reflection and Refraction, will be found in my papers in the *Phil. Trans.* 1815, p. 129, and 1830, p. 69, 133.

[2] *Comptes Rendus des Seances de l'Academie des Sciences*, tom. xxii. p. 961–993, 1845, 17th Mars.

[3] *Comptes Rendus, &c.*, 27 Juillet, 1846, tom. xxiii. p. 195, and 3 Août 1846, tom. xxiii. p. 233. "M. Brewster," says M. Babinet, "a sans doute eté guidé dans sa recherche par des vues theoriques; autrement il me parait peu probable qu'il eut fait, par observation seul de la polarization atmospherique, le decouverte remarquable de ce point neutre si difficile a reconnaitre, et que, depuis lui j'avais plusieur fois tenté inutilement de retrouver."—*Ib.* p. 235.

[4] The lines in the spectrum were ill defined, from unequal refraction in the air.

Were the sky sufficiently clear, we should doubtless find a secondary neutral point accompanying the primary one below the sun; but in our climate, there is little chance of this phenomenon being distinctly observed.

In his observations on the antisolar *neutral point*, M. Arago observed, that it sometimes deviated from the plane passing through the antisolar point and the eye of the observer; and he justly ascribed this deviation to the influence of luminous clouds situated out of this plane. The same phenomenon takes place in reference to the other neutral points, though the deviation is, in these cases, less distinctly seen, from the interference of the sun's light. But it is not merely the position of the neutral point that is influenced by the intrusion of light different from that of the sky; the degree of polarization is always affected whenever we measure it in parts of the sky which have luminous clouds or illuminated terrestrial objects in their vicinity, or any luminosity in the field of view of the polarimeter. If the neutral point happens to be above or below any such object, its *distance* from the antisolar point or from the sun is increased or diminished.[1]

V.—ON THE MAXIMUM POLARIZATION OF THE SKY.

After having ascertained the position of the neutral points, or *Poles of no-polarization* as we may call them, the next most important element to be determined is the *Maximum polarization of the atmosphere.*

When a ray of common light is reflected from any transparent body, at an angle whose tangent is equal to the index of refraction, it is completely polarized; or when a ray of light, completely polarized in a plane inclined 45° to the plane of reflection, is reflected from any such body, its plane of polarization is brought into the plane of reflection; that is, *its plane is turned round* 45°. Hence complete polarization is measured by a rotation of 45°. When the polarized ray is reflected at angles *above* or *below* the angle of maximum polarization, its plane is less turned round, and its rotation is more or less than 45°, according as the angle of reflection is more or less distant from the angle of maximum or complete polarization.[2]

Different degrees of rotation below 45° may also be produced by the refraction of the polarized ray at one or more surfaces of glass,[3] the rotation increasing with the angle of incidence. Hence we may measure the *degree of polarization* wherever it exists, by observing at what angle of incidence it is compensated or neutralized, by reflection from a transparent surface, or by refraction at one or more such surfaces. I have found the last method the most convenient, and have therefore constructed a *polarimeter*, which measures the polarization of the sky, by observing with it either the varying angle at which it is compensated or neutralized by a fixed number of thin glass plates, or the varying number of refracting surfaces, by which the same effect may be produced at a fixed angle, capable also of being changed.[4]

With a *polarimeter* thus constructed, I have determined that the maximum polarization of a clear blue sky is equivalent to a rotation in the plane of a polarized ray of 30°; and that this maximum takes place at a distance of from 88° to 92° from the sun, and in the plane passing through the sun and the zenith. This maximum is of course dependent on the state of the atmosphere, both with respect to its magnitude and position; but we shall assume 30° as its amount, and 90° from the sun as its position in a normal state of the atmosphere, and when the sun is in the horizon.

VI.—ON THE FORM OF THE LINES OF EQUAL POLARIZATION IN THE ATMOSPHERE.

It is obvious, from the phenomena already described, that the polarization of the atmosphere, produced by the reflection of the sun's light from the matter, which composes the atmosphere, in planes passing through the sun, the point of reflection, and the eye of the observer, would have been equal in circles of which the sun and the antisolar point are the centre, had there been no disturbing causes, or had the atmosphere been a perfectly transparent medium. In this case the polarization would have been complete, or 45°; and this maximum would have occurred at a distance from the sun, the half of which was the polarizing angle of the medium. There is obviously, however, a cause depending on the zenith distance of the polarizing point of the sky, which acts in opposition to the polarization produced by reflection, and compensates it at the neutral point already described. When the sun, therefore, is in the horizon, these two actions are rectangular, as in biaxal crystals; and we must, therefore, determine the form of the lines of equal polarization when the sun is in the horizon, and when the atmosphere is perfectly pure. When viewed, consequently, in their general aspect, the phenomena of atmospherical polarization may be represented by the formula—

$$R = 30^\circ\ (\text{Sin. D. Sin. D}')$$

Where R = Rotation, or degree of polarization, and
D and D′ = The distances of the point whose polarization is required from the *two* neutral points.

This formula would make the lines of equal polarization *Lemniscates*, as in biaxal crystals, and, consequently, the polarization in the horizon greater than in the zenith, which is contrary to observation. I have, therefore, added a correction, depending on the zenith distance and azimuth, which makes the formula coincide better with observation, namely:—

$$R = 33\tfrac{1}{4}^\circ\ (\text{Sin. D. Sin. D}') - 6^\circ\ 34'\ (\text{Sin. Z. Sin. A.});$$

Z being the zenith distance, and A the angle of azimuth.

Assuming, therefore, that the distance of the neutral points from the sun and from the antisolar point is 18° 30′, when the sun is in the horizon, that the atmosphere is perfectly pure and uniformly transparent, the lines of equal polarization will have the forms and the degrees of polarization represented by the formula. The direction of the polarization follows the same law as in biaxal crystals, the lines corresponding with the black hyperbolic branches in the polarized rings produced by these crystals, being distinctly seen with the polariscope.

VII.—ON THE CONSTRUCTION OF THE MAP OF THE LINES OF EQUAL POLARIZATION.

Had the map been on a greater or a less scale than it is, it might have been desirable to appropriate a single curve to every single degree, or to every two degrees of rotation or polarization. On the present scale, the curves would have been too numerous and close, had there been one to each degree; and with only one to each two degrees, they would have been too distant, in so far as that the form of the curves round the neutral points would not have been sufficiently seen. I therefore adopted such a number of curves, viz., 18½, as enabled me to get the curves, No. 2, continuous round each neutral point. Hence, the formula became—

$$N = 20^\circ\ 5'\ (\text{Sin. D. Sin. D}') - 3^\circ\ 9'\ \text{Sin. Z. Sin. A},$$

or in the plane passing through the sun and the zenith, in which Z and A become zero.

$$N = 25^\circ\ 5'\ (\text{Sin. D. Sin. D}')$$

In the zenith itself we have $N = 18^\circ\ 45'$, and at P, P′, we have $N = 0$.

The curves thus obtained do not represent values of N in degrees of rotation, but in numbers, each of which is equal to 1°626. Hence R = N 1°626, and the distance between each curve is 1°626. The following table contains the Rotations or degrees of polarization, indicated by each of the curves numbered from ½ to 18.45 in the map:—

Values of N.	Corresponding degrees of Rotation, or Polarization, or values of R.
½	0°813
1	1 626
1½	2 439
2	3 252
2½	4 065
3	4 878
4	6 504
5	8 130
6	9 756
7	11 382
8	13 008
9	14 634
10	16 260
11	17 886
12	19 511
13	21 137
14	22 764
15	24 396
16	26 016
17	27 642
18	29 268
18.45	30 000

Hence the maximum polarization of the atmosphere, as measured by a Rotation of 30°, is equal to that produced by reflection from a plate of glass at an angle of 65½°, and with a refractive index of 1.4826, or to that produced by a surface of diamond at an angle of 75½°. The number of refractions at a given angle, or the angle, with a given number of plates of glass, at which a rotation of 30° is produced, will be found from the formula in my paper on the *Compensations of Polarized Light.*[5]

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[1] On the 16th May 1842, barometer 30·3, the sun was faintly seen through a thick haze. At 5h 49′ A.M., the polarization was *positive* all the way from the sun to the horizon, so that the neutral point below the sun was below the horizon. Immediately afterwards, the *sun* was quite hid—a great glare supervened, and a *quaquaversus polarization* was observed, in which the polariscope gave no coloured bands.

On the 17th May, at 6h 30′, the sun's disc was quite white through a thick haze, and there was no *neutral point either above or opposite the sun*, the polarization being everywhere *positive*. When the haze is thicker on one side of the plane passing through the sun's spectrum, the neutral point deviates from that plane.

[2] See *Philosophical Transactions*, 1830, p. 69.

[3] *Ib.* ib., p. 133.

[4] See the *Transactions of the Royal Irish Academy*, vol. xix., part 2.

[5] *Transactions of the Royal Irish Academy*, vol. xix., part 2, p. 13.

EXPLANATION OF THE MAP.

The system of lines of equal polarization is represented in two separate projections. In Fig. 1, they are projected on a plane passing through the zenith of the observer, and perpendicular to the line joining the observer and the sun. The line HH is therefore the horizon; and HZH′ Z′ the plane passing through the zenith at right angles to the line joining the sun and the observer. The sun is represented rising or setting at S′, twice as large as it is; and the neutral points discovered by M. Babinet and myself, are shown at P, P′. The lines of equal polarization are coloured *yellow*, and the number of the curves, from 1 to 18, and the degree of rotation or polarization corresponding with each are marked upon them. The lower half of the figure supposed to be below the horizon, shows the system of curves in the atmosphere of our antipodes, to whom the sun is rising when he is setting with us, or setting when he is rising.

In Fig. 2, the system of curves of equal polarization is projected on the plane of the horizon HHHH, the sun rising or setting at S, S′ being the antisolar point. The neutral point of M. Arago is shown at P, and that of M. Babinet at P′, the zenith point being at Z.

As the sun *rises* above the horizon, the lines of equal polarization change their form, and the degree of polarization varies at points of the sky whose distance from the sun is invariable. The neutral points *above* and *below* the sun approach his disc till he reaches the meridian, when the distance of each from the sun is a *minimum;* they then separate again, and attain their maximum distance, when he reaches the horizon. In countries where the sun passes across the zenith, these two neutral points coincide with the sun, when he reaches the zenith, and again separate.

As the sun descends beneath the horizon, the neutral point of M. Arago separates from the antisolar point, and when this point is first seen in the morning before sun-rise, its distance from the antisolar point is a maximum; it gradually approaches that point till the sun rises, and also till the neutral point itself reaches the horizon, when its distance from the antisolar point is a *minimum.*

When the altitude of the sun is 45°, the distance x of the neutral point above the sun is about 13° 5′, and the distance x' of the neutral point below the sun 6° 42′; at other altitudes we have

$$\left.\begin{array}{l} x = \Delta \cos A, \text{ and} \\ x' = \dfrac{\Delta \cos A,}{\text{Tang. Z,}} \end{array}\right\}$$

Δ being 18¼° A, the sun's altitude, and Z the zenith distance of P′, the neutral point below the sun.

An interesting paper, entitled *Delle Leggi della Polarizzazione della Luce Solare nella Atmosphera Serena, communicato con Lettera al* David Brewster, LL.D., F.R.S. Lond. *et* Edin., *membro delle Principali Academie di Europa*, del Prof. A.B. Francesco Zantedeschi, will be found in the *Raccolta Fisico-chimica Italiana*, tom. i. fascic. 10: 1846. The details in this paper are chiefly historical. The results obtained by M. Zantedeschi himself, which are of a general nature, differ in several respects from mine; but whether this difference arises from a difference in the methods of observation, or from the different states of the atmosphere under which the observations were made, I am not able to determine.

In a Memoir *on the Polarization of the Atmosphere*, which, I trust, will soon be published in the *Transactions of the Royal Irish Academy*, I shall give a full account of my observations, and enter more deeply into the subject than would have been proper in the preceding popular explanation of a Map of the Lines of Equal Polarization.

TERRESTRIAL MAGNETISM.

BY COLONEL SABINE, R.A., D.C.L., V.P.R.S.*

THE first person who appears to have taken a correct view of the system of Terrestrial Magnetism was Dr Edmund Halley; with whom also the method originated, which is still employed, of representing the magnetic declination in different parts of the earth, by lines traced on a globe or map, connecting together places where the declination is of equal amount. The declination—or, as it was more frequently called, the "variation" of the needle, until it was found that the needle is subject to many "variations," depending upon many different causes—is the term employed to designate the amount by which the pointing of the compass-needle differs from the true geographical north. Thus, places where the needle points due north are connected together by a line called a line of 0°, or of no declination; places where the needle points 5° to the east of north are connected by another line called the line of 5° east declination; and so forth. Lines thus traced on the surface of a globe, or on a map, bring together in one view a number of facts obtained by the labour of many independent observers. They were called at first Halleyan lines, from their inventor, but are now commonly known as Isogonic lines, or lines of equal declination. A similar mode of systematic representation has subsequently been adopted in regard to the Isoclinal lines, or lines of equal inclination to the horizon of a freely suspended needle, not limited, as the compass-needle is, to motion in a horizontal plane only; and to the Isodynamic lines, or lines of equal magnetic force, acting on the needle and giving it its direction. By these three systems of lines the magnetic direction in both the horizontal and vertical planes can be at once seen for any point on the surface of the globe, as well as the amount of the force by which the needle is retained in that direction; and the variations in direction and force can be compared and reasoned upon. Hence the declination, inclination, and magnetic force, have acquired the name of the three magnetic elements.

The first map of the lines of declination was published by Dr Halley in 1701, on his return from a voyage made expressly for magnetic observations, in a ship placed at his disposal by King William III., in which he visited the east and west coasts of the Atlantic Ocean, as well as many of its islands, from one hemisphere to the other, as far as the ice would permit him to go. At the time of the publication of this map Halley was forty-five years of age, and, in addition to his own observations, appears to have been previously, for above twenty-five years, a diligent collector of all trustworthy observations made by others. His attention had been attracted to the subject at an unusually early age, since we know, from his own statement, that his first observations on the change of the declination in London were made in 1672, which was a year before he left school. His first memoir on terrestrial magnetism was presented to the Royal Society in June 1683, and appears as No. 248 in Vol. XIII. of the *Philosophical Transactions*, entitled "Theory of the Variation of the Magnetical Compass." His purpose in this memoir was to bring together in one view a number of observations of the declination made about one and the same epoch in different parts of the globe; and to show, 1°, their utter irreconcilability with the hypothesis of Bond, published in 1676, which attempted to explain the magnetic variations by "two magnetical poles, and an axis inclined to that of the earth;" and 2°, to propound, apparently for the first time, the theory of "four magnetical poles or points of attraction—two near each pole of the [geographical] equator;" and to show that "in those parts of the world which lie adjacent to any one of these magnetical poles, the needle is chiefly governed thereby, the nearest pole being always predominant over the more remote."

We must here remark that Halley employed the term "magnetical poles" in its original physical acceptation; meaning thereby the points on the surface of the earth, considered as a magnet, where the resultant of the forces of all the particles attains a maximum. Other definitions have since been introduced; such as, for example, the points on the earth's surface where the *horizontal component* of the magnetic force becomes 0 or zero. But this is a geometrical rather than a physical definition. Halley applied himself simply and directly to the solution of the physical problem which terrestrial magnetism presents, and used the expression of the "poles of a magnet" in the sense in which the term was then, and is still, understood in physics.

Halley's demonstration of the impossibility of reconciling the observed variations by "two magnetical poles and an axis inclined to that of the earth," was based upon a comparison of the declinations observed in different parts of the globe, with the necessary consequence of that hypothesis that "under the same meridian the variation should be in all places the same way." The failure was general, and in some localities excessive; for example, the entrance of Hudson's Strait, and the mouth of the River Plate, are nearly under the same meridian: in the one the declination was nearly 30° to the west, and in the other 20° to the east. Subsequent writers have shown, by the maps of the inclination and of the force which have since been formed, the irreconcilability of the phenomena of those elements also with the hypothesis to which Halley objected, and which now deserves notice chiefly in a historical point of view, as a first conceived though very insufficient mode of explanation, but which may still be occasionally met with in elementary works, in which due care is not taken to keep pace with the advance of knowledge, or in which the development of a geometrical conception is more regarded than a true exposition of the facts of nature.

For the four poles, which, after a long and careful discussion, Halley considered himself to have proved to be adequate to the explanation of the declinations observed in all parts of the globe, he assigned the following positions at the period at which he wrote—viz., two poles attracting the north end of the needle in the northern hemisphere, and two poles attracting the south end of the needle in the southern hemisphere. Of the two north poles, one more powerful than the other, and which he called the American Pole, in the meridian of about 246° east of Greenwich, or about the longitude of the middle of California; and one less powerful in or near the meridian of the British Islands—the latitude of both being within the arctic circle. Of the two south poles, one, also more powerful than the other, to the south of New Holland, and a second, weaker, about 20° to the west of the Straits of Magellan, or in about 265° east of Greenwich—the latitude of both the southern poles being within the antarctic circle. Occupying the positions thus named, the two stronger and the two weaker poles were shown to be sufficient to explain the declinations that were at that time observed in the temperate and frigid zones of each hemisphere, where the direction of the needle chiefly depends on the counterpoise of the forces of two magnetical poles of the same name; whilst in the torrid zone, and particularly under the equator, the declinations were susceptible of a similar explanation when respect was had to all the four poles.

At the time when the memoir was written from which these particulars are taken, viz., 1683, Halley was fully aware that the declination at any one point of the earth's surface is not a constant quantity, but is affected by a variation, which, as it was observed to be continuous in one direction for many successive years, obtained the name of "secular," in contradistinction to "periodical," which is the designation given to variations oscillating about a mean amount, and returning to the same in periods of ascertained duration. Halley was aware that the magnetic declination underwent a secular change from year to year, which was different in amount and in direction in different parts of the globe, and that, as a necessary consequence, both the situation and the form of the lines of declination, determined for a particular epoch, must be regarded as subject to a corresponding change. If we revert to his memoir of 1683, we find that, after expressing his "hope that he has not lost his pains and study in this difficult subject, believing that he has put it *past doubt* that there are in the earth four magnetical points or poles which occasion the great variety and seeming irregularity which is observed in the variations of the compass," and his "regret that, from want of sufficient data, he was unable to proceed geometrically in determining the exact position of the poles" at the epoch at which he wrote, he takes express notice of the further difficulty which would be occasioned by the "*change* in the variation, one of the discoveries of this last century, and which shows that it will require some hundreds of years to establish a complete doctrine of the magnetical system;" whilst, with the sagacity which characterised in so eminent a degree many of the physical speculations of this great philosopher, he conjectures that the secular changes in the declination would be found to proceed from, and to correspond with, a motion of two at least of the magnetic poles which he had indicated; but "whether these poles move altogether with one motion, or with several—whether equally or unequally—whether circular or libratory—if circular, about what centre—if libratory, after what manner—are secrets," he adds, "as yet utterly unknown to mankind, and are reserved for the industry of future ages."

In a subsequent communication to the Royal Society in 1692 (*Philosophical Transactions*, Vol. XVI., No. 195), Halley reverts to his former memoir, and states, as the result of his continued attention to the progress of magnetical observation, the confirmation of his belief that the phenomena of secular change indicated the existence of, and might be conceived to be produced chiefly, if not wholly, by the motion of that part of the terrestrial magnetic system of which the two weaker poles, one in the north and the other in the south, were the representatives; the motion of the northern of these being to the east, and of the southern to the west; and foreseeing that, from the extent of the problem to be solved, its solution would far exceed the limits of his own life, bequeathed to posterity, and particularly to the Royal Society, of which he was so long a distinguished ornament, the continuance of researches which he had so happily commenced, in the following memorable words: "The nice determination of the periods of the motion of the poles, and of several other particulars in the system, is reserved for remote posterity. All that we can hope to do is to leave behind us observations which may be confided in, and to propose hypotheses which after-ages may examine, amend, or refute; only, I must take leave to recommend to all masters of ships, and others, lovers of natural truth, that they use their utmost diligence to make, or procure to be made, observations of these variations in all parts of the world, as well in north as in south latitudes, after the laudable custom of our East India commanders, and that they please to *communicate them to the Royal Society*, in order to leave as complete a history as may be to those that are hereafter to compare all together, and to complete and perfect this abstruse theory."

Although the time appears to be still distant at which a true physical theory of terrestrial magnetism, embracing all the phenomena, may be propounded, we may with satisfaction affirm that the present generation has not been wanting in the endeavour to procure materials for the only secure foundation of such a theory, by carrying out, to a far greater degree than has ever been previously attempted, the counsel contained in the words which have been just quoted. Originating in recommendations proceeding from the British Association for the Advancement of Science,—and warmly and powerfully supported by the Royal Society with the weight due to its long-established reputation,—the observations required for the delineation of the three magnetic elements corresponding to the present epoch over the whole accessible surface of the globe, both on land and on the ocean, have received the assistance of our own and foreign governments, in a measure which is second only to the aid afforded to astronomical research; a circumstance the more worthy of acknowledgment, inasmuch as researches which precede the proposition of a Physical Theory, however essential they may be to its induction, do not so obviously or so certainly recommend themselves to the popular view, as those which, at each successive step, supply an additional confirmation of the truth of principles which are justly regarded as amongst the greatest achievements of the human intellect. It is therefore especially for sciences which are in their infancy that the countenance and fostering care of societies formed for the promotion of the sciences in general, each according to its particular need, are most required; and they have certainly not been wanting in the case of terrestrial magnetism.

Whilst, in connection with magnetic observatories, magnetic surveys have been prosecuted chiefly by the aid of public funds, over large portions of the continental spaces, the acquisition of the necessary materials over the ocean, constituting, as it does, the larger portion of the accessible part of the earth's surface, has been the work of British officers, supplied with instruments, and, when necessary, with specific instructions, from the Government establishment at Woolwich. The results thus obtained from 1840, when the observatories began, until 1854, when the late war commenced, amounting to many thousand observations of the declination, inclination, and force, at many hundred distinct geographical positions on the ocean, have been transmitted to the office from which the instruments and instructions proceeded, for reduction and co-ordination previous to their communication to the Royal Society, in fulfilment of Dr Halley's recommendation. A part, though as yet but a comparatively small part, of these has been published, in a reduced and co-ordinated form, in several memoirs in the *Philosophical Transactions*, and will be followed by the remainder as speedily as the means at the command of the individual who is charged with this honourable task will permit. In the mean time, an opportunity has been taken, which has been afforded by the editor of the Physical Atlas, of representing, on a scale for which great precision is not required, such an approximate delineation of the three systems of lines as is given by a first and provisional co-ordination. It will be understood, therefore, that the accompanying maps of the three elements in the year 1840 do not profess to be more than the first step towards that more perfect representation of the phenomena, which will be given when the mass of accumulated materials shall have been more completely digested.

Besides the observations over the ocean, having for their object the general delineation of the three magnetic elements, particular points in the magnetical system have been the subjects of special examination by scientific expeditions. Amongst these may be cited, in chronological order,—1°. The voyages of the writer of this notice in the Isabella, Hecla, Pheasant, and Griper, in 1818-1822, whereby the geographical position of the point of greatest force in the northern hemisphere was shown to be distinct from the point of 90° of inclination, and to be in a much more southerly latitude than had previously been imagined. 2°. The voyage of Captain, since Admiral, Duperrey in the Coquille in 1822-1825, undertaken expressly to trace, round the oceanic portion of the globe, the line in which the needle has no inclination. 3°. The journey of MM. Hansteen, Erman, and Due, in 1827-1829 to Eastern Siberia, to ascertain the position at the time of the minor magnetic pole in the northern hemisphere. 4°. The expedition in 1840-1843 of Captain Sir James Clark Ross in the Erebus and Terror, and subsequently in 1845-1846 that of Captains Moore and Clerk in the Pagoda, to ascertain the positions of the southern poles of magnetic force, and generally to furnish materials for magnetic maps in that hemisphere. 5°. The magnetic survey of the British possessions in North America, by Lieutenant, since Lieutenant-Colonel, Lefroy, in 1843-1844, having for its specific objects the precise determination of the position of the American point of maximum force, and of the amount of the force at that point. 6°. The magnetic survey of the Indian Archipelago, undertaken by Captain Elliot of the Madras Engineers, in 1846-1850, at the expense of the East India Company, having for its object the procurement of correct maps of the three elements in a part of the globe where the phenomena were previously very imperfectly known. And to these, of which the results have all been published, may be added determinations of the three elements in British India, by the MM. Schlagintweit, at the expense of the East India Company; and in Northern and Central Africa, by Mr Vogel, at the expense of the British Government—(in both cases with instruments prepared at Woolwich). These two last undertakings are still in progress.

It must not, however, be supposed that between the time of Halley and the date of these modern researches the phenomena have not been observed, or that there have not been persons by whose assiduity and labour the observations of different epochs have been brought together and compared. Amongst the latter there is one name, that of Hansteen, which it would be unpardonable to omit in a notice, however brief, of those to whom terrestrial magnetism in its early stages has been most materially indebted. In his great work, entitled *Magnetismus der Erde*, published at Christiania in 1819, he has collected together in one view all the observations of antecedent times, and has formed from them maps of the declination for 1600, 1700, 1710, 1720, 1730, 1744, 1756, 1787, and 1800; and of the inclination for 1600, 1700, and 1780; enabling those who may desire to do so to trace the progressive operation of secular change in those two elements from the earliest date to which observations ascend. Two of these maps—viz., the Declination for 1787, and the Inclination for 1780, have been reproduced on the present occasion, and are exhibited in comparison with the corresponding maps of the epoch of 1840, because they are the most perfect of the earlier maps, and because the elapsed interval, being that of the last half-century, is the best suited to convey an approximate notion of the change which may take place in the next half-century.

Mr Hansteen's work contains no map of the third element—viz., the magnetic force. The observations of this element commenced with those of De Rossel and Von Humboldt, about the beginning of the present century. The first general map of the lines of equal magnetic force over the globe was contributed in 1837, with an accompanying memoir, to the Transactions of the British Association for that year, by the writer of this notice. The isodynamic map for 1840, which is here given, is a revision of the map of 1837, with additional particulars derived from a provisional calculation of materials subsequently acquired. The several lines of equal force have the values 0.9, 1.0, 1.1, &c., given to them, in reference to a certain arbitrary unit first employed by M. de Humboldt (who has promoted, and may, indeed, be said to have originated successful generalisations in so many branches of terrestrial physics), as a means of comparing with each other the measures of the force made by different observers in different parts of the globe. The unit assumed professed to be a measure of the force at a certain station in South America, where M. de Humboldt had vibrated a magnetic needle which he had previously vibrated in Paris, and, from the well-known law, that the force at two stations is in the inverse ratio of the squares of the times of vibration, inferred that, if the force at the South American station were taken as the unit, the force at Paris would be expressed by 1.348. The law which is here referred to presupposes, however, the invariability of the magnetism of the needle which is vibrated at the two stations: and to be assured that this condition was fulfilled, it would have been necessary that M. de Humboldt's needle should have been brought back to Paris, that the permanence of its magnetism might have been verified. Accidental circumstances prevented this condition being complied with, and doubt might have been thrown thereby upon the strict comparison between Paris and the station selected to supply the unit of the system; but it was soon seen that the purposes of a general comparison might equally be fulfilled by virtually dropping the South American station altogether and taking Paris as the base, and 1.348 as the measure of the force at Paris. A participation in the advantages to be derived from a common base was obtained for British observers by a very careful comparison made in 1827 between the force in Paris and in London, by vibrating several needles alternately at both stations, by which the value of the force in London was ascertained to be 1.372, in terms of M. de Humboldt's arbitrary scale. These values have been subsequently employed in the co-ordination of all observations having London or Paris as their base station.

The advantages which have resulted from the adoption of this arbitrary unit, in bringing together the otherwise disconnected determinations of different observers, have undoubtedly been very great; but it had one inherent defect; it assumed a constancy of force at the base station, and afforded no means of comparing observations made at the same place at different epochs; whereas we have reason to believe that the force, as well as the declination and inclination, is subject in all parts of the globe to secular change. A mode of meeting and surmounting this difficulty had been indicated by M. Poisson; but we are indebted to the *Intensitas Vis Magneticæ Terrestris ad Mensuram Absolutam Revocata*, published by Mr Gauss at Göttingen, in 1833, for the exposition and practical introduction of a method of determining the absolute magnetic force of the earth at the spot where the experiment is made, independently of the magnetic moment of the magnets employed in the experiment, and expressed in terms of standards of weight and linear measure, and of recognised subdivisions of time. By a repetition of the experiments at a subsequent epoch, the amount of secular change which may have taken place in the interval becomes known; and by multiplying the determinations at well-selected and widely-separated stations, light will be thrown on the important question, whether the magnetic force of the earth, as a whole, be itself a constant, and the secular changes at different points of the surface merely variations of distribution; or whether the whole terrestrial magnetic force be itself subject to increase or decrease. Such determinations, however, require to be made with a degree of accuracy, which demands that, where undertaken, they should be a *primary* object. As the absolute values in different parts of the globe have the same relation to each other that the arbitrary values have, it is only necessary that the *ratios* of the two scales at any one station should be known, to enable all values assigned in the arbitrary scale to be converted into absolute ones. Experiments for this purpose were made at the Toronto Magnetic Observatory, and have furnished the comparative scale which is engraved on the face of the present isodynamic map.

It has been remarked above, that Halley's demonstration of the irreconcilability of the phenomena with the two-polar hypothesis rested on the observations of the declination only; and that the maps of the inclination and of the force which have been formed since his time have confirmed the conclusion. This may be shown by the maps which accompany this notice. According to an hypothesis of two poles and an axis inclined to that of the earth's rotation-axis, the two magnetic poles should be points of 90° of inclination, and also of maxima of the force; the great circle equidistant from them should be both an isoclinal line of 0, and an isodynamic line of half the value prevailing at either of the poles; whilst the inclination and the force should increase together, continuously, on either side of this line—which might, in such case, with propriety be called the magnetic equator. These are necessary conditions of the hypothesis; and we may at once satisfy ourselves that they are not conformable with the facts, by examining the phenomena on some parallel of geographical latitude either in the isodynamic or in the isoclinal map. Let us take, for instance, the parallel of 50° of north latitude, and compare the magnetic conditions which it actually presents with those which it ought to present on the two-polar hypothesis. In conformity with the latter, we ought to find a maximum of inclination and of force at the intersection of some one meridian with the parallel in question, and a minimum of inclination and of force at the intersection with the same parallel of the opposite geographical meridian; whilst, intermediately, both elements should diminish continuously when the parallel is traced in either direction from the maximum to the minimum. Now, if we consult the isodynamic map of 1840, we find, on the parallel of 50° of north latitude, a maximum of force (about 1.86) near the 274th degree east from Greenwich; proceeding westward, we find on the same parallel a minimum (about 1.28) near the 169th degree of east longitude; proceeding still westward, we find a second maximum (about 1.60) near the 110th degree east, and a second minimum (about 1.31) near

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* Mr Keith Johnston acknowledges with much gratitude the presentation of this Memoir, and the elaborate Drawings for the accompanying Plate, as valuable contributions to the *Physical Atlas*, from his esteemed friend the Author.

the 25th easterly meridian. These are all well-marked features, and, by their correspondence with the inflections of the adjacent lines, show themselves to be the characters of a system which divides the parallel, not into two, but into four divisions—*four*, neither more or less. This double curvature of the isodynamic lines is somewhat less strongly marked as the magnetic poles of the northern hemisphere are receded from and the equatorial parts of the globe approached; but becomes more marked, on the other hand, in the higher latitudes, until the points of minima of some one of the lines meet and unite, forming lemniscates, or curves resembling the figure of ∞, enclosing two spaces of unequal area, within which the isodynamic lines of higher value appear as ovals around two centres of unequal force. The isoclinal map of 1840 exhibits correspondingly, but with somewhat less deep inflections, the division of the geographical parallel of 50° into four magnetic segments, by maxima of inclination about the meridians of 120° and 285° east, and minima about 50° and 168° east. Here also the double curvature becomes more and more conspicuous as the higher latitudes are approached, indicating the probable existence of the lemniscate form in the isoclinals of regions within the arctic circle, which have as yet been but imperfectly examined.

Did we possess maps of the isodynamic lines of the time of Halley, or, as in the case of the declination, trustworthy observations of the same or even an earlier date,—such as those from which Hansteen has constructed a map of the declination lines in 1600 for certain parts of the globe,—we should be able to judge with more confidence than we are as yet able to do, of the facts of the secular change which the magnetical system of the earth has since undergone. In tracing back these changes we are thrown back principally upon the declination, with some little assistance from the observations of the inclination, which began to be regarded with suitable care towards the middle and end of the seventeenth century, but with no assistance whatsoever from the magnetic force, because the secular changes of this element can only be made known by the comparison of *absolute* determinations at different epochs, and the method of making these dates only from 1833. The office, therefore, of those who cultivate this science in the present day is much the same as in the days of Halley; their labour must be chiefly given to leaving behind them "observations which may be confided in, and which will form as complete a history of the present state of the phenomena as may be, for those who are hereafter to compare all together, and to complete and perfect this abstruse theory." The task of sowing that a future generation may reap, may not be a very encouraging one, but it has been, to say the least, zealously encountered. The present positions of the four magnetic poles hage been, as already noticed, the objects of special researches—one at the expense of the Norwegian, and three at the expense of the British Government. By the first-named of these the weaker pole of the northern hemisphere has had its position approximately ascertained by the expedition of MM. Hansteen, Erman, and Due, to Siberia in 1828 and 1829, and is placed by them in or about the meridian of 120° east, the measure of its force being about 1.76 in the arbitrary scale, or 13.3 in the absolute scale of British units. The nearly contemporaneous position of the stronger pole in the northern hemisphere has been determined by the survey executed by Lieut.-Colonel Lefroy in 1843 and 1844, in the British possessions in North America, to be in 52° 19′ north latitude, and 268° east longitude—the measure of the force being 1.88 in the arbitrary, or 14.2 in the absolute scale. The ratio of the forces at the two attractive points is, therefore, as 14.2 to 13.3, or nearly as 1.07 to 1, which may be regarded as an approximate measure of the comparative extent and amount of their influence. The change of longitude of the stronger pole, since Halley placed it in or about the meridian of the middle of California, appears to have been small; but, on the other hand, the weaker pole, which is now found in Siberia, was placed by Halley near the meridian of the British Islands; and, adopting Halley's mode of reasoning, the present disposition of the lines of declination corresponds to this change. The easterly declination which existed in England in the middle of the seventeenth century, and led Halley to infer the vicinity of a point of attraction to the east of our meridian, is now found in Siberia, in about 80° of east longitude, indicating that the attracting point is now to the east of that meridian; whilst, if we refer to the maps of intervening epochs in Hansteen's *Magnetismus der Erde*, we find, in all the intermediate interval of time, the evidence of a conformable *progressive* change. The inclination also, which, at the same epoch (about 1670), was between 75° and 76° in London, has since progressively diminished to its present value (about 68° 30′), which would correspond with an increasing distance of the attracting point from our meridian. The isoclinal lines in our vicinity must have been considerably depressed towards the equator in 1670 in comparison with what they are now, and we at present find this depression a maximum (from the effects of the weaker pole at least) in or about the meridian of 120°; whilst to the east of that meridian the effect of the present secular change is to increase the inclination,—an effect which would correspond to the approach of the pole; and to the west of 120° the effect of the secular change is to diminish the inclination,—as if by the recession of the pole. The annual decrease of the inclination in London since 1670 does not appear to have taken place uniformly, but to have been greater in the earlier than in the later part of the interval. This would also correspond with the increasing distance of the point whose retrocession produces the decrease. In a memoir presented very recently to the Royal Society of Sciences at Copenhagen, M. Hansteen has called the attention of magneticians to the facts connected with the secular change of the inclination in Europe, and particularly to the progressive diminution in the rate of decrease. With us this rate appears to be at present nearly uniform, from observations made with every precaution to insure accuracy in the years 1821, 1838, and 1854, (reported in a note appended to the English translation of Arago's Meteorological and Physical Essays, pp. 364-366). The present uniformity of rate in Britain may possibly be due to our more westerly position.

The antarctic expeditions of Sir James Clark Ross, and of Captains Moore and Clerk, have given us the disposition of the lines of the three elements in the southern hemisphere corresponding to the present epoch, with a correctness which promises to leave but little to be desired, at least in those parts which are accessible to navigation. The knowledge thus acquired assures us that the phenomena present the same obvious and decided features of a duplicate system as do those of the northern hemisphere. In comparing the present geographical distribution of the magnetic forces in the south with that which prevailed in the days of Halley, we find the situation of the stronger pole in about the meridian of 134° east, still "south of New Holland," and differing, therefore, but little from the longitude assigned to it at the end of the seventeenth century. On the other hand, the position of the weaker pole, which Halley placed 20° to the west of the Strait of Magellan (about 265° east of Greenwich), must now be placed between 30° and 40° to the west of the above-named position. In this case, also, the maps of the declination for intervening epochs in Hansteen's *Magnetismus der Erde*, show by the successive changes in the positions of the lines of declination in the vicinity of the weaker pole (where consequently its influence predominates), that the westerly movement has been progressive. In the southern hemisphere, as well as in the northern, the position of the pole of principal force has been found to be in a distinct locality from the point of 90° of inclination, and to be considerably more distant from the pole of the earth than was imagined before the corresponding inference was drawn at the northern hemisphere. The observations of the Erebus and Terror in 1841 assign its latitude a few degrees north of the antarctic circle. The measure of the force at the principal maximum appears to be somewhat greater in the southern than in the northern hemisphere—a consequence probably of the greater proximity to each other of the two southern poles: their least distance in longitude from each other is under 90°; in the north it is nearer 150°. The nearer the two poles in the same hemisphere approach to each other, the more the force at each will be increased, and the stronger will be the force in the space between them on the side where they are nearest to each other; whilst on the other, or larger interval, there will be a counterbalancing weakening of the force. To this we may ascribe the ascent of the weaker lines of force to the high latitudes in the South Atlantic, and the great inflection of the line of least intensity to the south of the equinoctial, between the continents of Africa and America. The approximate value of the force at its principal southern maximum cannot be taken at less than 2.0 of the arbitrary, or 15.14 of the absolute scale.

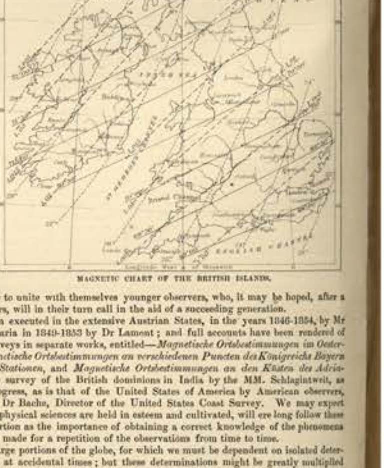
As the inflections of the lines in the temperate and torrid zones are so much influenced by the situation and form of those in the higher latitudes, observations within the arctic and antarctic circles have a more than ordinary value in promoting a true and clearly-characteristic representation of the magnetic distribution at any particular epoch. Those regions are indeed seldom visited, except when some great geographical problem interests the public mind sufficiently to cause attempts to be made for its solution, but at such times the physical sciences profit by the occasion. The several expeditions for the discovery of a navigable passage between the Atlantic and Pacific Oceans, have given opportunities for magnetic observations (with instruments and instructions prepared at Woolwich) in this very important quarter; and it may be confidently anticipated that, when all the observations which have been made by the different arctic expeditions shall be co-ordinated and placed before the public, the gain to terrestrial magnetism will be found to be very considerable. In particular, they may be expected to furnish a delineation of the isoclinal ovals nearest to the principal maximum of force, which occupy higher geographical latitudes than do the isodynamic ovals which surround the point of maximum; and to show the direction of the principal axis, which passes through the central points of the loops of the isoclinal lemniscates. The secular change in the direction of this axis appears to be very influential in determining the character and amount of the secular change of the inclination in the high latitudes generally. The observations which would probably contribute in the highest degree to its present correct delineation, would be such as might be made by a magnetic survey in Siberia between the parallels of 70° and 74°, and on the great circle connecting the sea discovered by Wrangel, north of the Siberian Islands, with that discovered by Kane in the extension of Baffin Bay to the north of the 80th parallel.

The completion of maps of the three elements, delineating as correctly and as extensively as may be possible the results of observations of the present time, is a necessary preliminary step to another mode of representing the phenomena, which is much esteemed by many—viz., by trigonometrical formulæ, composed of the sines and cosines of a sufficient number of equidistant longitudes, taken on a sufficient number of equidistant parallels of latitude, having coefficients whose numerical values are assigned by calculation from the values given by the maps of the three elements at the points thus symmetrically distributed over the globe; or by a second method, exemplified by M. Gauss, in his work entitled *Allgemeine Theorie des Erdmagnetismus*, Leipzig, 1839: in this method the calculation is effected by formulæ of another class, in which the coefficients are also derived from the maps for a certain number of stations, which, to render the representation of the phenomena complete, should be symmetrically distributed over the globe. As a requisite preliminary for either of these methods, therefore, it is important not only that the maps should be as correct as possible, but also that they should be as complete as the difficulty of access to certain parts of the earth will permit. The data employed by M. Gauss for the deduction of the coefficients in the work referred were far short of what would be required for a perfect representation, being restricted to twelve points on each of seven parallels in the equatorial and temperate zones, where M. Gauss regarded the facts as best assured. It is to this insufficiency of the data on which the calculations rested, that the discrepancies between the results of theory and of observation are no doubt chiefly to be ascribed. This is the view taken by M. Gauss himself, who expressly describes his theoretical results as a "first attempt, with very scanty means, from which we are entitled to expect little more than a rough approximation," fully anticipating that a "fresh calculation hereafter, resting on more perfect data, may cause material alterations of position, more particularly in the high latitudes, and especially in the high latitudes of the southern hemisphere," where no observational data beyond the 40th parallel were employed. Under these disadvantages the accordance of the calculation, within the limits of the parallels from which the data were derived, is extremely encouraging for a repetition when more perfect and complete data shall have been prepared. The two maps on a polar projection, which occupy the lower corners of the accompanying plate, exhibit the isogonic, isoclinal, and isodynamic lines, computed by M. Gauss's formulæ for the space comprised between the latitudes of 65° north and 90° north. They will be found instructive to those who desire to study the general disposition of the lines, notwithstanding the insufficiency of the data on which the first calculations of M. Gauss's theory are based.

Some writers have imagined, from the occurrence of the expression in M. Gauss's *Allgemeine Theorie*, that "there are on the earth only two magnetic poles," that a variance exists between the conclusions of Gauss and those of other eminent magneticians—Halley and Hansteen, for example—who had preceded him. But this is a mistake, occasioned by sufficient heed not being given to the different signification of the term "magnetic pole," when used by Gauss, from that in which it was employed by Halley and others. To avoid ambiguity, Gauss defined the meaning of the term when it should occur in his own writings—as, "the points on the earth's surface where the horizontal intensity = 0, and where, therefore, generally speaking, the inclination = 90°," remarking at the same time that this is quite a different application from its employment by others to signify "those places where the total force is a maximum, *i. e.*, greater than anywhere in the surrounding vicinity." It is in this latter sense that the term is employed by Halley and the other philosophers who are erroneously supposed to be at variance with Gauss regarding "facts;" whereas their only difference regards the application in which a particular term is used. Gauss finds, by the calculations of his theory, two points in the northern hemisphere where the total force is a maximum. These are Halley's "*Poles*, or points of greatest attraction." Employing coefficients, derived from observational data near the present magnetic epoch, Gauss finds by calculation the two points of maximum to be one in North America, and one in Siberia; so does Hansteen, and so do all others who are conversant with the observations by which the facts of nature are made known to us. Gauss's calculations would have been very much in fault if they had not accorded with observation in this respect; but they not only do so accord, but reproduce these points with very remarkable approximation—viz., the stronger in 54° 32′ north, 261° 27′ east, and the weaker in 71° 20′ north, and 119° 57′ east. A comparison with the map of the total force in the reports of the British Association for 1837 (which furnished the numerical data on the adjacent parallels for M. Gauss's coefficients), will show how closely the calculation approximates to the map. It must be admitted, however, that there is an inconvenience in the use of terms which are understood by different writers in different senses. M. Gauss himself remarks, that "it tends to confusion to call dissimilar things by the same name." There is no danger of being misunderstood when certain points are expressly designated as "maxima of the forces," and certain others as "points of 90 of inclination."

Having brought before our readers in an earlier part of this notice, the anticipations of Halley regarding the future progress of the theory of terrestrial magnetism, we may permit ourselves to transcribe those of the great German geometrician whose work has been just referred to. "For the satisfactory refinement and completion of the calculation, it will be requisite to make much higher demands than have been hitherto complied with as to the data to be furnished by observation. Their accuracy at all the points employed ought to be such as has hitherto been obtained at a very few only; they should be cleared from the effects of irregular changes, and should be all of the same epoch. Next to this, the chief desideratum is to obtain observations of the three elements from points in those larger spaces of the earth's surface where such observations are still wholly wanting. Every new station will have for the general theory an importance proportionate in great measure to its distance from those we actually possess. After a sufficient interval of time shall have elapsed, the elements may be determined afresh for a second epoch, and their secular changes may be thence deduced. In the course of the present century these alterations will no longer appear uniform, and the examination of the course and progress of the elements will offer to men of science inexhaustible materials for research." However complete the delineation of the elements may be made, either directly from the observations themselves, or by the intermediation of formulæ, the representation will still be only that of the magnetic distribution at a single point of time in that great system of secular change, which constitutes the most mysterious part of the physical problem of which we seek the solution. The changes which are thus effected proceed from causes which act with surprising uniformity and regularity through a long succession of years. To take but a single example: We know, from thoroughly trustworthy observations, that the westerly declination at St Helena has increased during the last two hundred years at a nearly uniform rate of 8′ in a year; and not only so, but that this annual increase takes place in *equal aliquot portions in each of the twelve months.* (*Proceedings of the Royal Society*, Vol. VII., No. 4.) Unable as we find ourselves to connect these changes with any physical phenomena, either terrestrial or cosmical, with which we are acquainted, we are as yet wholly without a clue to guide us to the discovery of causes at once so general and so systematic. Their discovery will undoubtedly rank as one of the greatest discoveries in the progress of natural knowledge. The period of its accomplishment may be distant, but the path which conducts towards it is certain. What the present generation has done must be repeated by those who are to follow, stimulated by the example, and profiting by the experience of their predecessors. From the increased scientific acquirements of our naval officers (to which the arctic expeditions have greatly contributed), and from the recent establishment of a distinct branch of the public service charged with the superintendence of the scientific observations to be hereafter made at sea, we may confidently anticipate that the oceanic observations, so zealously commenced, will be carried on with the advantage of those improvements in instruments and methods which experience has suggested; and that the results will be co-ordinated and published in successive maps at such intervals as may appear desirable.

In looking forward to the sources from whence the data required for successive magnetic maps of the continental spaces may be expected to be supplied, our most hopeful prospects appear to rest upon the possible extension of magnetic surveys, and upon their periodical repetition; on these, therefore, it may be desirable to say a few words. The first in chronological order of these undertakings was the survey of the British Islands, executed in the years 1834 to 1838, by five members of the British Association desirous of carrying out one of the recommendations of that body assembled in Edinburgh in 1834. A full description of the instruments employed, and of the modes of comparing and verifying them—of the processes of observation at 172 stations distributed over the British Islands,—and of the methods by which the several determinations were co-ordinated, and the lines of equal direction and force derived from them—is published in the Reports of the British Association for 1836, 1837, and 1838. The annexed diagram is a graphical representation of the results of this survey, exhibiting the three systems of lines corresponding to the mean epoch of January 1, 1837, obtained by observations comprised between the years 1834 and 1838 inclusive. Each line in this diagram has its position assigned by the observations which are nearest in value to itself, and which are employed for that line only; the position and direction of each line is thus rendered a distinct and independent determination. By diminishing the values of the lines of declination and inclination, 7′ a-year for the declination, and 2′.8 a-year for the inclination (reckoning from the mean epoch of the diagram), we may adapt it approximately to any of the succeeding years. The values of the isodynamic lines express the ratio of the force to that in London taken as the unit; by multiplying these values by 1.372, we obtain the corresponding values in M. de Humboldt's scale; and by multiplying them by 10.384, we obtain the value in the absolute scale of British units. Twenty years have now passed since this survey was undertaken, and it is thought by those who were concerned in making it (all of whom are still living), that the proper time for its repetition has nearly arrived; and they deem that the most advantageous proceeding will be to unite with themselves younger observers, who, it may be hoped, after a similar interval of twenty years, will in their turn call in the aid of a succeeding generation.



MAGNETIC CHART OF THE BRITISH ISLANDS.

Similar surveys have been executed in the extensive Austrian States, in the years 1846-1854, by Mr Kreil, and in and around Bavaria in 1849-1853 by Dr Lamont; and full accounts have been rendered of these admirably conducted surveys in separate works, entitled—*Magnetische Ortsbestimmungen im Oesterreichischen Kaiserstaate, Magnetische Ortsbestimmungen an verschiedenen Puncten des Königreichs Bayern und an einigen auswärtigen Stationen*, and *Magnetische Ortsbestimmungen an den Küsten des Adriatischen Golfes.* The magnetic survey of the British dominions in India by the MM. Schlagintweit, as already noticed, is now in progress, as is that of the United States of America by American observers, under the superintendence of Dr Bache, Director of the United States Coast Survey. We may expect that other States in which the physical sciences are held in esteem and cultivated, will ere long follow these examples; and that, in proportion as the importance of obtaining a correct knowledge of the phenomena is recognised, provision will be made for a repetition of the observations from time to time.

There will still remain large portions of the globe, for which we must be dependent on isolated determinations by casual travellers at accidental times; but these determinations might be greatly multiplied if geographical societies would extend to physical geography a portion of that encouragement and regard which they now bestow almost exclusively on descriptive geography; and thus become centres to which travellers, designing to visit particular countries, could apply for advice in respect to the physical observations which it might be most interesting to make, and where they might find the most suitable instruments ready prepared, with such instructions as would be most likely to be useful. By such an extension of their objects the Societies would themselves be gainers, in the increased recognition of their public usefulness, and in the additional information and interest imparted to their members.

We have spoken of the science of which we are treating as *in its infancy*; scarcely more advanced is that kindred branch of terrestrial physics which should make known to us, by the only secure path of experiment and inductive reasoning, even the most elementary facts respecting the physical condition of the materials which occupy the space between the surface and the centre of the earth,—the locality in which, in the judgment of the most eminent magneticians, we are to seek for the causes of the terrestrial magnetic force. Halley's opinion in this respect is well known; and it is without doubt one of the most important conclusions which Gauss derived from the investigations of his *Allgemeine Theorie*, that by their means "the fallacy of the hypothesis which would place the causes of terrestrial magnetism in space external to the earth, may be looked upon as proved;" and that "the agents of the greater part, at least, of the magnetic force of the earth are situated exclusively in the interior of the earth." The experiments in which Mr Hopkins is engaged, on the increase produced by pressure in the temperature of fusion of the materials of the earth, hold out to us the prospect of becoming acquainted with their condition, in regard to fluidity at least, at depths which were previously approached only by conjecture. The first general results of these experiments are understood to have been such as to lead Mr Hopkins to the "unavoidable conclusion that the earth must be solid at the centre;" a conclusion which involuntarily brings to recollection Halley's hypothesis of an internal Terrella, occasioning the duplicate magnetic system as well as the phenomena of secular change which show themselves at the surface of the earth; an hypothesis which, whatever may have been thought of it in other respects, had at least the merit of boldly confronting all the known difficulties of the magnetical problem to be solved.

We have said that Gauss was led by his investigations to the conclusion that the causes of the *greater part* of the magnetic phenomena observable at the surface of the earth must be sought in its interior. From this conclusion he expressly excepted those comparatively minor magnetic influences which produce variations oscillating around a mean value, and returning to it in periods of various duration. To investigate the causes of these by careful determinations of their periods, and by the comparison of these with periods depending on known terrestrial and cosmical relations, was the office for which the magnetical observatories were principally instituted; and by their means the fact has been established of the existence of magnetic variations at the surface of the globe, which, though very small in comparison with the magnetism of the earth itself, attest distinctly, and without doubt, the direct magnetic influence of the sun and of the moon. These variations constitute what may with propriety be regarded as a distinct, though closely connected branch, appertaining rather to the cosmical than to the purely terrestrial relations of magnetical science, into which, as we have arrived at the limits of our space, we forbear to enter.

PLATE 24

ON THE GEOGRAPHICAL DISTRIBUTION OF PLANTS YIELDING FOOD.

BY ARTHUR HENFREY, ESQ., F.R.S., F.L.S., &c.

PRINCIPLES.

1. The primary condition of the existence of any species of plant is its absolute creation, of which we know nothing.

2. But we assume each species to have been created but once in time and in space, and that its present diffusion is the result of its own law of reproduction, under the favourable or restrictive influence of laws external to it.

3. The most important external laws are those regulating climate, since every species can flourish only within certain narrower or wider, but always fixed, limits of temperature, humidity, &c.

4. Climate depends primarily on latitude, since this indicates distance from the source of heat and degree of obliquity of the beating rays.

5. Latitude is counterbalanced by altitude above the level of the sea, since the rarefaction of the atmosphere and the increased waste of radiant heat cool down the elevated points in such a manner, that successively higher belts, upon a tropical mountain, exhibit analogous characters to zones of increasing latitude upon level regions.

6. Both latitude and altitude are greatly modified by aërial and oceanic currents, which disturb the fluid media, air and water, and cause them to distribute very irregularly the heat they have absorbed; whence arise numerous complications both on a large and on a small scale.

7. The arrangements of the land and water on the globe greatly modify climate, by their influence on the currents just mentioned, and by the different behaviour of land and water in regard to absorption and radiation of heat.

8. From this difference it results, that large tracts of land produce dry climates, with excessive variations of temperature; while large expanses of water produce equable humid climates.

9. Every species of plant requires certain physical conditions, but these may be special or general.

10. If special, the plant will be incapable of wide diffusion.

11. If general, the diffusion will be proportionately extensive.

12. Intermediate conditions of all degree may exist.

13. The plants most cultivated by man are those furnishing large quantities of alimentary substance under very general conditions.

14. Agriculture bears a very close relation to civilization.

15. But the laws of diffusion under human agency vary with the stages of civilization.

16. Races in an early condition of civilization carry with them their plants, and grow them wherever the climate permits.

17. At this time, plants are little cultivated for luxuries, and even for a long time afterwards such plants are little transplanted, since their consumption is insufficient to stimulate such enterprise.

18. The extension of the cultivation of some plants becomes limited by the advance of civilization, since increased freedom of communication renders it no longer expedient to cultivate under severe climatal difficulties. Hence the polar limits of several plants cultivated in Europe have retreated southward within comparatively recent times; such as those of the vine and the sugar-cane.

19. The extension of civilization extends the limits of cultivation of plants into favourable regions; especially of plants yielding luxuries, since there is an increased demand for the latter which the original sources become insufficient to supply; for example, coffee, &c.

20. It must be assumed that the native localities of plants are those best suited for their spontaneous growth; but this does not hold universally, so far as regards their cultivation.

21. Cultivation not only extends the limits of the diffusion of plants over a larger area under an equal climate, but enlarges the limits of the capacity of plants to support varied climatal conditions, at the same time increasing their productiveness. The improved varieties of the potato, which are modified states, are produced under and capable of sustaining a very wide variation of climatal conditions.

22. In temperate climates, annual plants have their polar limits fixed chiefly by the mean temperatures of the summer months, while the limits of many perennials correspond more closely with the lines of excessive temperatures of July and January. Thus the polar limits of the growth of the common cereals depend upon the presence of a certain amount of heat between late spring and early autumn; if the same amount of heat is distributed between early spring and late autumn, the maximum temperature is insufficient to ripen the seed, as with barley in the Færoë Islands. On the other hand, the vine is limited in the north of Europe, in the west by the amount of summer heat requisite to ripen the grape, and in the east by the cold of winter becoming so great as to destroy the plants.

23. Annual plants require a certain amount of absolute heat to enable them to ripen their seeds. The mode of distribution of this heat will cause variation of the growing seasons in different climates. Thus, an annual which receives a certain sum of heat in Northern Europe between March and September, will receive the same amount between May and July in a more southern latitude, and will run through its course of growth so much the quicker. Moreover, it may receive an equivalent sum of heat in the course of a certain number of colder months in the more southern latitudes, and thus become an object of winter culture there, or even be made to yield two crops in one year. Flax is a summer crop in Russia, and a winter crop in Egypt. But a limit exists to this law. Plants remain at rest, even if not killed, below a certain degree of temperature, and only vegetate sluggishly at a temperature a little higher; so that, in a northern latitude, a plant may receive a certain sum of heat in six or seven months without ripening fruit, while the same sum of heat received in a shorter time in the south causes perfect maturation. This is because the temperature is too equable in the former, and, never rising high enough to stimulate the plant into fruiting, this merely vegetates, and produces only leaves or barren flowers. On the other hand, excessive heat may check the power of a plant in the warmer latitude, although, with annuals, this ordinarily only converts the plants from summer into winter growers, as far as mere temperature is concerned. As regards annual cultivated plants of importance, such as grains, where those of the temperate climates are absent altogether from the hotter climates, it is usually because the proper tropical grains displace them, as being, from other causes, preferable objects of culture.

24. With regard to the perennials of temperate climates, the excessive heat of the tropics bars their progress towards the equator, by deranging their laws of growth. Thus the vine runs to waste, as it were, and will not produce fruit, within a certain distance from the equator (corresponding pretty closely with the limit within which it is no longer profitable to cultivate wheat, even in the cooler months), since its proper alternations of rest and activity are interfered with. The tropical perennials, limited towards the poles, on the other hand, by the frosts of winter, are subject to similar derangement of their physiological functions, from the absence of the stimulus of heat, since they will vegetate, producing abundance of leaves, and withstand the cold seasons, much beyond the line where they cease to ripen fruit. For example, the date-palm is grown, for the sake of its foliage, on the north coast of the Mediterranean, while it produces fruit only at a few points in the extreme south of Europe, and properly belongs to Africa.

EXPLANATION OF THE LARGE MAP,

ILLUSTRATING THE GEOGRAPHICAL DISTRIBUTION OF THE PRINCIPAL PLANTS YIELDING FOOD.

The large Map of the world is divided into zones, distinguished by the prevailing characters of the grain cultivation. The polar and equatorial boundaries of these zones are marked by broad transverse colour lines, which, taken with the isotheral and isochimenal lines laid down in narrow red and blue lines, indicate the relations of the predominant grains to climate. Within these zones are found circumscribed but very irregular colour patches; these indicate natural regions, defined by climate, the effect of latitude modified by elevation, prevailing currents of air, water, and similar causes: in these regions will be found letters indicating the kind of grain forming the predominant objects of cultivation within them.

The names of various food-plants yielding substances analogous to those obtained from the cereals, are printed in black letters over regions where they are largely produced, either by cultivation or in a wild condition.

The names in blue letters are those of a few characteristic timber trees or other plants useful in the arts, which by their presence give indications of climate or general physical conditions.

The names of the principal fruits (using the word in its ordinary, and not in its botanical signification) are printed in red ink: as in the case of the plants indicated by the blue letters, the boundaries of the regions producing these fruits are very vague, and therefore the names are printed across the situation probably representing the centre of their diffusion. As it would have caused confusion to have printed the names of the tropical fruits upon the Map, they are given in a note at the foot, in their ordinary appellations, with the botanical names of the plants producing them.

PLANTS YIELDING IMPORTANT ARTICLES OF FOOD.

FOOD-PLANTS BELONGING TO THE FAMILY OF THE GRAMINACEÆ.

The corn, grain, or cereal grasses constitute the most important group of plants cultivated as food for man; and those of the Old World are identified most strongly with the civilization of the human race, since we not only find them mentioned in the earliest historical records, but in spite of all researches their native origin cannot be certainly determined. Barley is indeed stated by Kunth to be a native of Tartary and of Sicily. Spelt was found in an apparently wild state in the north of Persia; and a kind of oat closely resembling the cultivated species was found by Koch in the Caucasus. Strabo believed wheat to be a native of the banks of the Indus. But two difficulties oppose themselves to all attempts to settle these questions. In the first place, the occurrence of an apparently wild form in any given spot is no proof of its being indigenous, unless it can be shown that human inhabitants have never sojourned there, since the latter are mostly accompanied by their corn-plants, and these may readily run wild in a deserted locality. This objection has been urged on good grounds against all attempts to settle the origin of our existing corn-grains. In the next place, it is declared by many persons, that our cultivated grains are by no means in their natural condition, but are what may be called pathological products arising out of long cultivation. Quite recently, a distinguished French botanist, M. Fabre, has published some observations which are quite startling in this respect, since he states that he has obtained wheat by a gradual passage, through twelve generations, from the wild grass called *Ægilops ovata*. Such a statement requires extensive confirmation before it can be accepted, since our historical data prove that the ordinary grains have not altered under culture since the time of the Greeks, and even of the Egyptians, as is proved both by monuments, and in the latter case by actual seeds, which have been preserved. If the cultivated forms have not altered in any important particulars during three thousand years, we should hardly expect the original forms to be so readily modifiable as to be converted in a few years into what have hitherto been regarded as even distinct genera. Still, experiment is better than theory; and although in the present state of the evidence we should be inclined to believe that the original localities of our corn-grains, probably situated in Western Asia, have been rendered unrecognisable by the influence of cultivation, it is still possible that we may have the wild progenitors of some or all of them persisting in a wild state, in which the characters are so different that they pass for different species, and even members of different genera.

Barley (*Hordeum*), stated to be indigenous in Tartary and Sicily, must, on the hypothesis of single centres, if this be true, have had a natural area of distribution extending across to the intermediate countries, and thus the real original centre remains unknown. It was cultivated by the Egyptians in the time of Moses (Exodus, ix. 31), and by the Persians and Babylonians (Herodotus). It was the grain earliest grown in Greece, where it is still the most frequent in some regions. The Romans cultivated summer barley (*H. distichum*, or *galaticum*), and winter barley (*H. cantherinum*), but subsequently only on the hills, where it was the principal food of the poor. It seems to have been introduced into Germany by the Romans at an early period, and was extensively cultivated, in particular for the prepartion of the national beverage beer (from the old German word *bere*—barley). It has gradually become so much extended that it occupies the northernmost points of grain-culture—a circumstance owing to its peculiar requirements of temperature, which it meets with in the north—about 70° north latitude in Lapland, at 67° to 68° in Western Russia, and 68° in the eastern parts; on the north-west coast of Europe it does not extend so far, since the mean temperatures of the summer months fall, and the climate is rendered less favourable by excessive moisture: thus it extends from the north of Scotland to the Shetlands, and is grown in the Færoës, but seldom ripens properly there, so that the seed-corn is mostly brought from Denmark. It will not grow at all in Iceland. In the warmer regions it occupies a corresponding region upon the hills, and is grown at an elevation of 3500 feet on the Alps. In Asia it is grown to the extreme limits of grain in the north, and in the elevated regions, such as the Himalayas (at 12,000 feet), in the south. In the New World, when introduced by cultivation, it reaches the northernmost climatal limit in North America, and extends along many degrees of latitude, at a certain elevation, on the slopes of the South American Andes.

The common two-rowed barley, *H. distichum*, is grown either as a summer or winter grain, the sowing in autumn retarding the ripening, and converting it into "winter barley." But the especial value of barley lies in its quick ripening, hence the importance of the kind of six-rowed barley (*H. hexastichum*), called *bere* or *big*, which occupies the northernmost limits of grain in Europe; for it is capable of running through its cycle of growth and ripening the seed in the interval between the late spring and early autumn.

Rye (*Secale cereale*) was known to the Persians, but does not appear to have been cultivated by the Greeks or Romans; it was known to Pliny, who regarded it as a bad kind of grain, only fit to satisfy hunger under extreme want. It was valued more highly in the time of Charlemagne, under whom its price seems to have borne the proportion of 4 to 1 towards that of oats. At present it is largely cultivated in northern Europe, not indeed much in Great Britain, but wherever the land is poor and little ameliorated by the systems of culture. In Russia, Germany, and part of France, it is the commonest grain, and furnishes the bread of at least one-third of the population of Europe. Its northern limit in Norway is 67°; in Sweden, 65° to 66°. In Russia it follows the same curve as oats; in Siberia, our data do not admit of separating these two from barley. Rye is little cultivated in the south of Europe. It is cultivated with the other introduced northern grains up to the limits of corn-culture in Canada, and on the north-west coast of North America.

Oats (*Avena sativa*).—The native country of the oat is supposed to lie in the Caucasus; and Professor K. Koch believed that he found the original plant indigenous there, but it appears that there is some difference in the character of the ears; perhaps, however, so slight a one as to have arisen in cultivation. Oats seem to have been far less extensively grown than any other grain among the ancients, as is the case also at the present time. It is stated that the Persians grew oats, but chiefly for fodder, and they were only used for human food in times of scarcity. There appears to be no notice of oats by the Roman and Greek authors; but they were grown extensively in Germany, especially about the regions on the north of the Swiss Alps, in the time of Charlemagne. At present, oats are grown to the extreme north of Scotland, 58° 40′; in Norway, to 65°; and in Sweden to 63½°, therefore not quite so far as rye. In Russia the limit seems to coincide with that of rye. The culture extends southward to the northern parts of Germany and France, but not much south of the latitude of Paris. Over the greater part of the area oats are grown for feeding horses; but in Scotland, Lancashire, and in some parts of North Germany, as in the southern portion of Westphalia, oaten bread, or oat-cake, still forms a staple in the food of the poor. Oats are cultivated to the corn-limit of North America, but apparently not in South America. They are grown with advantage in elevated spots in Bengal, to the parallel of 25° north latitude, and have been introduced with the other European cereals into Australia and Tasmania.

Wheat (*Triticum*).—There exist numerous kinds of wheat, which some regard as species, others as merely varieties produced by cultivation, and these are grown in different proportions in different regions. The most important are the winter wheat (called *T. hybernum*), summer wheat (*T. æstivum*), and spelt (*T. spelta*). Wheat and spelt seem to have been cultivated in the earliest times by the Jews, the Egyptians, and Persians. The Greeks had several kinds of wheat, among which spelt is mentioned by Homer, and the one-grained wheat (*T. monococcum*) is supposed to have been indicated by Theophrastus. The Romans had three kinds of wheat, one of which seems to have been our summer wheat. Spelt appears to have been the kind earliest cultivated, since that kind called far (*T. zea*) gave its name (*farina*) to all flour. The better wheats gradually displaced the spelts in the plains and valleys, and they thus became restricted to the mountains, as at present. Summer wheat is the kind which ripens most quickly, and prevails in warm climates. It is cultivared in many parts of Europe. Winter wheat prevails in the north of Europe, and is generally sown in the autumn in England; but it is an annual, and may be sown in spring. If sown in spring, it acquires the habit of ripening more quickly, and this peculiarity may be increased by continuance of that mode of culture; hence arises what is called spring wheat, which is not specifically different from *T. hybernum*. Spelt is much cultivated in the south of Europe, in the south of France, Switzerland, Italy, parts of Germany, and in Spain, and can be raised in soils of inferior fertility. The northern limit of wheat in Great Britain is about 58° north latitude; in Norway, 64°; and Sweden, 62°; but it is not much cultivated beyond 60°. In the west of Russia it is at 60½°, and falls off gradually in the east. The polar limits in North America are not sufficiently ascertained, since the cultivation has probably not been pushed to its limits; but it is grown as far as 54° north latitude in the middle of the continent. The equatorial limit in the plains of the Northern hemisphere seems to lie not far distant from the tropic; but it grows luxuriantly on the plateaux of the intertropical regions of America, at 8000 feet or more above the sea. The possible limits of the culture of spelt are not ascertained, since the existing diffusion of this grain depends more upon the habits of men, and their systems of cultivation, than on climatal conditions.

Rice (*Oryza sativa*) seems, like the other cereal grains, of doubtful origin, for, although cultivated from time immemorial in Asia, it has not been certainly ascertained to exist there in a wild state; and, on the other hand, it has been stated (Martius) that it grows wild in the interior of South America, on the Rio Negro, and in Para; however, it is certain that it was not cultivated in the New World before the advent of the Europeans. The earliest notices of rice culture occur among the Persians; and this grain became known to the Greeks after the expedition of Alexander. The Arabians seem to have introduced it into Egypt, and it passed with the Moors into the warmer parts of Spain, and the Spaniards conveyed it into Italy about 1522. Columbus carried it to America on his second voyage (1493). At the present time it is the chief grain of the eastern and southern parts of Asia and the tropical archipelago, where it universally forms the food of the people. It is a common article of cultivation and of food in tropical Africa, Egypt, Nubia, Persia, Arabia, Asia Minor, the north of Africa, and is also grown in Greece, and parts of Italy, Spain, and America. It has spread through the southern states of North America, the West Indies, Venezuela, and Brazil. It requires a considerable amount of heat, together with abundance of moisture—conditions not commonly occurring together; so that, in the majority of cases, its cultivation is carried on by means of artificial irrigation. The grain contains a greater proportion of starch than wheat, potatoes, or maize, and is thus better adapted for exportation than any other farinaceous food. It is probably used as food by a greater number of men than any other plant.

Millets, &c.—The seeds of the various species of *Panicum* and *Holcus* are used as food in certain localities south of 45° and 47° north latitude. Thus, in Brittany, a millet, the grain of *Panicum miliaceum*, forms an important constituent of the food of the peasantry; and in parts of Italy, especially Tuscany, the sorgho or durrah (*Holcus sorghum*, *Sorghum vulgare*) is greatly used. It was introduced as *Milium indicum* in the time of Pliny, while *Panicum miliaceum* and *P. italium* seem to have been known in the time of Julius Cæsar. The Persians cultivated the durrah under the name of "Cenchrus." The greatest cultivation of millets, in the present day, is found in the countries of Southern and Western Asia, and Eastern Africa, especially in Abyssinia and the adjoining regions. There, species of *Panicum*, *Holcus*, *Poa*, *Eleusine*, and other genera of grasses, are largely grown for food under various names, all, however, being sufficiently alike to be classed as millets.

Maize or Indian Corn (*Zea Mays*).—The origin of the maize has been a matter of much dispute, and opposite opinions are entertained by competent persons even at the present time; but the balance of the evidence is in favour of its having been derived from the New World. In the first place, St Hilaire states that he found it wild in the forests of Brazil, while Tschudi states maize to occur in the graves of the ancient Peruvians; and it is well known to have been in general use in America at the time of the discovery by the Europeans. On the other hand, Fraas, Bousfons, and others, following Dodonæus, identify it with Pliny's *Milium indicum*, which was doubtless the Italian *meliga* or *melga*—the durrah (*Sorghum vulgare*, *Holcus sorghum*); and the name "Turkish corn," which prevails in some parts of Germany, probably arose from a misconception arising from its having been introduced in part through Turkey and Hungary. In the south-west of Germany it is called "Italian corn." The Spaniards found maize cultivated on the American coasts they first visited, and not only was the culture spread over South America, but in Virginia also. At present, maize is the most extensively diffused grain of the New World, and is grown from the southern extremity of Chile up to very high latitudes in North America, where the high summer-heat allows it to advance further than in Europe. It was brought to Europe by Columbus himself in 1493; by 1525 it was cultivated in fields in Spain. It became known in gardens in France and England about 1548–60. There were maize fields about Milan in 1575; and by 1610 it was an important article of trade with the Venetians, who probably carried it to the Levant, whence it passed up the Danube into Hungary, and, in the other direction, spread rapidly over the East. It has made its way into India, China, Japan, and the Indian islands, Sumatra, the Archipelago, the Philippines, &c., in ways of which we have no account. It was introduced into Guinea by the Portuguese as early as the sixteenth century. Maize is an annual, demanding only a certain amount of summer heat; and it is calculated that its northern limit in Europe should correspond prettly nearly with the isotheral line of 65°; but its actual boundary at present does not coincide with this, from various causes—commercial, political, and others; and it may be expected to extend much higher than at present in Eastern Europe. It is observed that, while the culture of the vine has been retreating south from economical causes, the maize, as unaffected by the same influences, has advanced; and it is probable that the limit of the vine, instead of lying north of that of maize, will ultimately fall altogether to the south of it.

FOOD-PLANTS OF OTHER FAMILIES.

The Potato (*Solanum tuberosum*, natural order Solanaceæ).—Potatoes were found in general cultivation in America by the early voyagers, and the real locality of their origin was long a matter of doubt. Ruiz and Pavon stated that they found it wild on the coast of Peru; Humboldt and Bonpland questioned this, believing it to be a native of Chile; but the concurrent testimony of Caldcleugh, Cruickshanks, Meyen, and Tschudi leaves little doubt that it exists in a wild state on the mountains both of Peru and Chile. The similarity of the name with the batatas or sweet potato causes some confusion in determining the date of its introduction into Europe; thus both Garcilasso and Peter Martyr mention plants under the name of *Papa* or *Tapas* (the modern Peruvian name of the potato), and under the name of *Ayis* or *Agies*, which may have been either one or the other. It is stated that Sir John Hawkins obtained potatoes from Santa Fé in 1565; but these may have been batatas; and if the former, they were forgotten. According to Humboldt, the potato was common in Spain and Italy at the period when the English obtained it from Virginia, for the Spaniards seem to have carried it into Italy and Burgundy between 1560–70. However this may be, it seems that Sir Walter Raleigh brought it to Youghal in Ireland in 1584 from Virginia, whither it must have been previously conveyed from South America, either by the slow intervention of the aborigines during a long period, or by the conquerors themselves. Seed-potatoes were given by Sir Francis Drake to Gerard the herbalist, who raised them in his garden in London in 1596, and published a figure of the plant; but it seems to have attracted little attention until Sir W. Raleigh imported it a second time in 1610 or 1623, and planted it in Ireland. In 1663 the Royal Society published rules for its cultivation, and it became widely diffused; yet it did not become an important object of cultivation until the middle of the eighteenth century, for it is not mentioned in gardening works of 1719, and in some districts it was only cultivated in the gardens of the rich as late as 1783–4.—(*Macculloch*). Clusius was very active in making known the potato on the Continent; but it made its way very slowly, both in Germany and France, where the well-known Parmentier did so much towards its diffusion. In Italy it can scarcely be considered widely cultivated even at the present day, but it has spread in greater or less extent from one extreme of Europe to the other—from Iceland even to Greece; and within the last seventy years it has been transplanted into Asia, to Bengal, the Himalayas, Ceylon, Madras, China, especially about Macao, Java, Kamtschatka, and the Philippines. It was carried to India about 1800 from the Cape of Good Hope, where it had been previously introduced by the Dutch. Malcolm introduced it in 1820 into Persia (where it obtained the name of Malcolm's plum); and since the European colonists have spread its culture in Australia, this valuable plant has become diffused throughout all the continents of the earth.

In warm climates, as in the place of its nativity, the potato thrives only on the hills; on the Andes it is found at 9000 to 13,000 feet, but it descends considerably lower on the sea-coast. On the South European mountains its upper limit is about 6000 feet, thus higher than the hardiest grain; and the like is seen in the polar limit, which lies beyond that of barley in Scandinavia, and advances into Iceland (where, however, the potatoes are little larger than a nut), while barley cannot be grown.

The Date (*Phœnix dactylifera*, natural order Palmaceæ).—The fruit of the date-palm is the most important article of food in some parts of Northern Africa, not only for man, but in some places even for cattle. This tree is a native of the north of Africa, and grows wild abundantly on the south slopes of the chain of Atlas. The Arabs call the strip of country between this and the great desert "the land of dates." It is cultivated along the whole Mediterranean coast of Africa, on the banks of the Nile, Sennaar, Arabia, and the coast of the Persian Gulf; it even extends at certain points into southern Europe, as about Malaga and in Algarve in the Peninsula, and in the south of Sicily (37° to 38°), while farther east the limits within which it ripens include Syria (34° to 35°), the south of Persia (29° to 30°), and the banks of the Indus (32° to 33°). Beyond this line it is still capable of vegetating without ripening fruit, and is cultivated in the open air for the sake of its leaves as far as 41° in Spain, on the Mediterranean coast from Hieres to Genoa, about Athens, and at Smyrna. Numerous varieties of the date exist in the date country of Africa (with which must be included the *oases* of Sahara), some of which are very highly prized, while others—namely, certain kinds in which the seeds are rarely perfectly formed, and which appear to have given rise to the fables of dates without stones—are so little esteemed that they are given to the horses and beasts of burden when barley is scarce. The northern limit of the maturation of date corresponds pretty nearly with the isotheral line 75°, and since the vegetation endures during nine months of the year, and the isocheimenes do not exhibit any important excesses of difference in this region, the annual isotherme of 65° may be regarded a pretty close approximation. At the isocheime of 55° the date is checked by frosts.

The Cocoa-nut (*Cocos nucifera*, natural order Palmæ), so valuable, not only for the food it yields, but from its timber, fibres, foliage, &c., is a native of Southern Asia, and has spread by cultivation almost universally throughout the intertropical regions, but is especially abundant in Ceylon, in Sumatra, Java, and the adjacent islands. It is said to advance as far north as Mocha, on the Red Sea, but will not grow in Egypt. It is cultivated on the Malabar and Coromandel coasts, and as far as Calcutta. It seems to require a mean temperature of 72°, which would almost correspond to the equatorial limit of the European grains.

Bananas and Plantains (*Musa sapientum* and *paradisiaca*, natural order Musaceæ) appear to have been originally found in the southern part of the continent of Asia, whence they were conveyed in unknown times to the Indian Archipelago and to Africa. The Europeans seem to have transported them into the New World, and they are now found in all regions lying between the tropics. According to Boué, *M. paradisiaca* is cultivated, as far as 34° north latitude, in Syria, and it is probably limited there by the winter cold. The limit in altitude in the equatorial regions of the New World seems to be fixed by the annual mean temperature of 18° to 20°, where the summer heat fails to ripen the fruits. The fruit of these plants is succulent and sweet, containing at the same time abundance of starch. Humboldt calculated that a given space of ground, planted with the banana, would yield forty-four times as much nutritive substance as the same extent of potato plantation, and a hundred and thirty-three times as much as a similar extent of wheat; but this point appears to require confirmation. There are many varieties of these plants—some, perhaps, different species—requiring different degrees of temperature. One species, the *M. textilis*, furnishes the *Manilla hemp*, of which very delicate muslins and handkerchiefs are manufactured.

Mandioc or Yucca (*Jatropha manihot*, or *Manihot utilissima*, natural order Euphorbiaceæ).—This is a shrub, with a fleshy root 1 to 2 feet long, and as thick as a man's arm, containing a considerable quantity of starch, together with a watery juice, violently poisonous in some varieties, capable of being rendered innocuous by heat. The meal, called *cassava*, is obtained by washing and bruising the root. The fecula called tapioca, is only the finer particles of the cassava starch dried into rough grains. The roots are also eaten roasted, when they become mealy. The mandioc is a native of Brazil, and is cultivated to about 30° on each side of the equator. It is arrested, like the banana, at about 3000 feet above the sea, in the intertropical Cordilleras. It is cultivated abundantly on the west coast of Africa, as in Congo and Guinea, but does not appear to have been introduced into Asia.

The Bread-fruit (*Artocarpus incisa*, natural order Urticaceæ) is a native of the South Sea islands, near the equator. In the original plant, such as is cultivated in Celebes, the pulpy fruit contains seeds of feculaceous character; but in the variety mostly cultivated, the seeds are ordinarily abortive, and the pulp contains the starch. The *jaca* or jack (*A. integrifolia*) has a larger but much coarser fruit. The bread-fruit is generally diffused throughout the Friendly and Society Islands, the Carolinas, &c. It has been transplanted to Mauritius, as also into the West Indies and Brazil, but does not appear capable of growing beyond the tropics, and thrives in a climate where the temperature of summer and winter do not differ more than 10° or 12°.

Buckwheat (*Polygonum Fagopyrum*, natural order Polygonaceæ).—It seems most probable that this plant was originally a native of the north-western regions of the Chinese empire; at all events, it was introduced into Europe from the East. The date as well as the manner of the introduction are involved in some obscurity, some supposing that it passed through Turkey and Greece into Italy and the French coast of the Mediterranean by means of the Saracens, about 1400–1500; while some suppose it to have been brought in during the Crusades. Its common names in France and Italy—*sarrasin*, *grano saraceno*—point to such an origin. It was cultivated on a large scale in Central Europe in the sixteenth century. At the present time it is cultivated extensively in the north-west of France, and in the greater part of Northern Europe, but most extensively in Siberia and the plateaux of Central Asia. It is not clear, however, how far the Siberian buckwheat (*Pol. tataricum*) is intermingled with the common species in Asia. The former was introduced into Europe in the eighteenth century. The value of the buckwheats depends on their capability of producing abundantly in sandy and moory soils, where the better corn-plants will not succeed. In such situations, it is frequently associated with rye, to the exclusion of all other grain.

The Yam (*Dioscorea alata*, *sativa*, *aculeata*, &c., natural order Dioscoreaceæ).—Many plants of this genus form large tubers, sometimes weighing thirty pounds, containing abundance of starch; and when cooked they are very wholesome. In some allied kinds, the deleterious watery juices which they contain are not entirely dissipated by heat. The yams commonly eaten are supposed to be natives of the Indian Archipelago, where they are largely cultivated; not extending, however, more than 10° on each side of the equator in the Old World. They are cultivated also in America, and in Cuba they form an essential portion of the agriculture.

Batatas, Sweet Potato, or Camotes (*Convolvulus batatas*, or *Batatas edulis*, natural order Convolvulaceæ).—This plant, supposed to be indigenous in the New World, is cultivated very generally for its tuberous roots in the intertropical countries, and as a pulse in temperate climates. Much confusion exists as to the time of its introduction into Europe; but it is supposed to have been brought to Spain by Columbus, and by Drake or Hawkins into England. In the latter, however, it cannot be cultivated in the open air, as it is up to 40°–42° in Spain and Portugal. It is cultivated on a large scale, up to 36°, in Carolina, United States.

Sago.—The plants yielding sago appear to be very numerous, but the best is obtained from two palms, *Sagus lævis* and *S. genuina*—trees forming large forests in most of the Molucca islands. The fecula is obtained from the soft internal substance of the stems, and it is said one tree yields as much as six hundred to eight hundred pounds. Many other tropical palms furnish inferior kinds of sago, while a similar substance is obtained from trees of a totally different class, the Cycadaceæ; and the starch obtained from the seeds of one of these, *Cycas circinalis*, in the Moluccas, was stated by Rheede to be true sago. This has been regarded as a mistake by subsequent authors. In Japan, a sago is obtained from the stem of *Cycas revoluta*; while other plants of the same family yield useful feculas in various countries—such as the Caffre-bread of the Cape, from various species of *Encephalartos*; a kind of arrow-root, from the seeds of *Dion edule*, in Mexico; and from *Zamia pumila*, in the Bahamas and other West Indian islands.

Tarro or Tarra (*Arum esculentum*, natural order Araceæ) is a starchy rhizome or tuberous stem, furnishing the common food of the natives of New Zealand, and some other islands of the Pacific.

Tacca or Tavoulou (*Tacca pinnatifida*, natural order Taccaceæ) is another rhizome or tuber, which affords a contingent to the food of the inhabitants of Madagascar—where it is said to have originated—and in Tahiti, and other islands of the Pacific. It is stated that it is also used, perhaps with other species, in the Moluccas and Malayan Islands; and it forms an article of diet in China, Cochin China, and Travancore, where it attains a large size, and is eaten with an acid, to subdue the acrimony.

Tara-fern or Tasmanian Fern-root (*Pteris esculenta*, natural order Polypodiaceæ) is used for food by the aborigines of Australia, and, it is said, in many of the South Sea islands. It is eaten roasted, and contains a certain amount of nutritive matter, but not enough to sustain vigorous life.

Quinoa (*Chenopodium Quinoa*, natural order Chenopodiaceæ) was extensively grown on the mountains of Peru when the Spaniards arrived there, and is still cultivated by the natives. The seeds are eaten cooked in a variety of ways; but it is of less importance since the introduction of wheat, and especially barley, into the same regions. The Peruvian mountaineers have several other peculiar cultivated plants—the ulloco (*Tropæolum tuberosum*), a tuber smaller than the potato; the oca (*Oxalis tuberosa*), an oval-shaped root; the mashua and the maca, two roots which are at present unknown to botanists.

Arracacha (*Arracacha esculenta* and *moschata*, natural order Umbelliferæ).—There appear to be two plants, furnishing the root known under this name. The first is described as generally cultivated in the plateaux of New Granada, while Tschudi states that the second is the root grown on the Cordilleras of Peru, where in many places it yields two crops a year. It is a nutritious tuberous vegetable, not unlike celery in flavour, as large as a parsnip.

It would occupy too much space to give an account of all the nutritious vegetables cultivated by man, and we must be content with indicating a few of the most important. The common vegetables of Europe do not require to be enumerated, but the chestnut may be mentioned, as forming the principal food of some communities at the foot of the Pyrenees and the Apennines. Arrow-root is obtained from a species of *Maranta*, in the East and West Indies, and from *Dion edule* (Cycadaceæ), in Mexico; tous-les-mois from a *Canna*, in the West Indies. *Lilium pomponium* is cultivated for its bulbs in Kamtschatka, where they are eaten as potatoes are by us. The *Ti* plant (*Cordyline ti*) yields an important article of food to the Sandwich islanders in its large roots. The large seeds of many pines are eaten, and those of *Araucaria Bidwilli* are probably of importance to the Australian aborigines. The tubers of various water-lilies are eaten in the East Indies. The leguminous plants furnish a vast variety of pulses, besides the peas, beans, lentils, commonly known in Britain. The St John's bread is the pulp surrounding seeds of *Ceratonia siliqua*, which seeds are largely eaten in the Peninsula, under the name of carobs or algarobas; while numerous other leguminous seeds are eaten, under this and other names, both there and in Spanish America. The ground-nut (*Arachis hypogæa*) is another legume, cultivated in Western Africa and in Brazil.

SMALL MAP—No. 1.—DISTRIBUTION OF THE PLANTS PRINCIPALLY CULTIVATED IN WESTERN AND CENTRAL EUROPE.

In this map, the various countries are divided into regions characterised by peculiarities in the agricultural operations, depending chiefly on the local physical conditions. On these regions, coloured differently, so as to render them distinct, but not really so sharply defined, are inscribed letters—ordinarily in groups of two or three—indicating the crops giving the principal character to the cultivation. The names of indigenous or introduced fruits, and other vegetable productions used for food, are printed in black letters over the districts where they flourish in cultivation. The most characteristic native trees or shrubs are printed in blue letters across the countries to which they belong.

The transverse black lines mark approximatively the limits set to the cultivation or natural growth of important food-plants and timber trees in Europe, by the increasing severity of the climate towards the north.

SMALL MAP—No. 2.—DISTRIBUTION OF PLANTS CULTIVATED FOR THE PRODUCTION OF ARTICLES OF FOOD, CLOTHING, DYEING, ETC., MORE OR LESS GENERALLY THROUGHOUT THE WARMER REGIONS OF THE GLOBE, WITH INDICATIONS OF SEVERAL IMPORTANT WILD PLANTS OF ANALOGOUS CHARACTER OCCURRING IN THE SAME REGIONS.

Sugar (*Saccharum officinarum*, natural order Gramineæ).—The sugar-cane appears to be properly a native of the tropical zone, and to have originated in the East Indies; but at present it is cultivated most extensively in both hemispheres, and thrives as far as 30° north latitude in Eastern Asia, 32° north latitude in North America, while in gardens, as high as 37° to 38° in Spain and Sicily. In the southern hemisphere, it does not appear to succeed beyond the tropic. It flourishes up to a considerable altitude in the warmer regions of both worlds; thus as high as 5000 feet or more in the Cordilleras of South America, and about 4000 feet in Nepaul. Sugar has been known in India from very early times, but it was used by the Greeks and Romans only as a medicine, and regarded as a rarity. It came by way of Arabia into the south of Europe, where it was cultivated in some places before the Crusades. The Moors appear to have introduced it into Spain. The Spaniards carried it to Madeira and the Canaries in the fifteenth century. It is stated by some that Columbus found the sugar-cane in America, but it seems very probable that the plant which he spoke of was the maize, from which a considerable quantity of sugar may be obtained. It is true that it has been cultivated from time immemorial in China and the islands of the Pacific, and possibly may have been conveyed into America in the migration by which that continent was originally populated. West India sugar was first cultivated by Europeans in Hayti or St Domingo, in the beginning of the sixteenth century. The Spaniards cultivated it also largely in Mexico, and the Portuguese in Brazil, early in the sixteenth century. In the seventeenth century, the English colonists of Barbadoes and Jamaica, and the French of Guadaloupe and Martinique, commenced its cultivation, and the French introduced it into Mauritius and Bourbon. On the discovery of Tahiti, a new species of sugar-cane was found by Cook and Forster. Captain Bligh transplanted it thence to Antigua and Jamaica, and this is now cultivated extensively in the West Indies, where it is called "canna d'Otaheiti," while the old cane is termed "canna creolia or criolla." At the present time, sugar is cultivated in the West India islands, Guiana, Brazil, in America; Mauritius and Bourbon, off the coast of Africa; Bengal, Siam, Java, the Philippines, and China, in Asia. All these places export sugar. It is also grown in the southern United States for home consumption (as in Louisiana), on the Gold Coast of Africa, and its culture has been recently successfully attempted in the Caucasian provinces of Asiatic Russia. It was calculated that 610,000 tons of sugar were produced in the year 1833, of which four-fifths were furnished by the New World, and one-fifth by the Old.

Coffee (*Coffea arabica*, natural order Rubiaceæ).—The coffee tree is a native of the highlands of Ethiopia, naturally growing 15 to 20 feet high; but in the West Indies it is cut so as to branch laterally, and thus forms a shrub or bush. The time of its introduction into Arabia Felix is unknown, but the first account of its use comes from thence, dating at the middle of the fifteenth century; and the coffee of Arabia, under the name of Mocha, is still renowned. Within a hundred and fifty years from that period, the use of coffee became general in the Levant and Egypt; while early in the eighteenth century, little was known of it in Western Europe. The first coffeehouse was established in Paris in 1672. About a hundred and thirty years ago, the coffee plant was carried by the Dutch from Arabia to Batavia; and at the present time it is cultivated in Java, the Philippines, Ceylon, East Indian peninsula, Bourbon, the West Indies, Surinam, Cayenne, and, above all, in Brazil. It is grown in smaller extent in many parts of Africa, as Mozambique, Angola; and Western Africa, Cape de Verd Islands, Madeira, &c. It has been estimated that not less than 476,000,000 pounds were produced in the year 1852.—(*Crawfurd*).

Within the tropics, the coffee plant thrives best at an elevation of 1200 to 3000 feet, and rarely grows above 6000 feet. It may be cultivated as far as 36° north latitude, where the mean temperature is about 70°.

Cocoa (*Theobroma Cacao*, natural order Byttneriaceæ).—The cocoa or cacao tree was cultivated by the Americans before the visit of Columbus, and the use of cocoa was very general in Mexico before the conquest by Cortes, where they not only prepared a beverage from it by infusion, but made it into cakes with maize-flour and vanilla. They called the beverage *Chocolatl*, whence our word *chocolate*, which, however, is applied to a similar composition, with sugar and various spices added. Chocolate was used as a necessary of life rather than a luxury by the earlier Spanish settlers in America, and its cultivation was very extensive. It was known in Europe as early as 1510, but not imported in any quantity until the beginning of the eighteenth century. It is now chiefly cultivated in Central America, on the river Magdalena, British, French, and Dutch Guiana; while, in the West Indian islands, it has given place, to a great extent, to coffee and sugar. Very little of that grown in Peru is brought to Europe, but part of the Chilian is sent to the South Sea islands, India, and Japan. The Spaniards introduced it into the Canaries and the Philippines.

Cotton (*Gossypium herbaceum*, *arboreum*, *barbadense*, and *peruvianum* or *acuminatum*, natural order Malvaceæ).—The cotton plants, belonging to the family of the Mallows, are trees and shrubs or herbs which grow spontaneously within the torrid zone in Asia, Africa, and America, and are cultivated to an enormous extent beyond those limits. Cotton manufacture has existed in India from the remotest antiquity, while the Americans brought cotton as a tribute to Columbus. Herbaceous cotton (*G. herbaceum*) is most largely cultivated; it is an annual 18 inches or 2 feet high, and is grown in the United States and other parts of America, in China, in Africa, and also in the Greek islands, Sicily, Calabria, and Spain. The shrub cotton, which is biennial or triennial, according to climate, is grown in most of the warmer countries where cotton is cultivated; while the tree cotton (*G. arboreum*) is grown in India, China, the interior and west coast of Africa, and in some parts of America. The kinds occurring in commerce are divided according to the countries whence they are exported: 1. *East India cotton* comes from the East Indies, including Mauritius, Bourbon, and the Philippines, the best being the Bengalee and Siamese (the Chinese is not exported). 2. *Persian cotton*. 3. *Levant cotton*, from Cyprus, Smyrna, Syria, Macedonia, Morea, and Egypt. 4. *European cotton*, from Malta, Sicily, Naples, and Spain. 5. *American cotton*: *a*. North America—from Georgia, Louisiana, Alabama, Tennessee, Carolina, and Florida; *b*. South America—from the West Indian islands, Guiana, Brazil, Peru, and the other South American states. The total amount of cotton grown annually was calculated some years back at 2,000,000,000,000 lb., but is now probably much more.

Indigo (*Indigofera tinctoria*, &c., natural order Leguminosæ) is a tropical plant, which has spread into both hemispheres within the parallels limiting its vegetation. It has been known in Europe for more than 2000 years, and was imported from India in the time of Dioscorides and Pliny; the Romans called it *Indicum*. It is uncertain, however, whether the pigment of the ancients was derived from the species now cultivated, since other nations who had no communication with India were acquainted with the dyeing properties of the species of *Indigofera*. The Americans possessed indigo before their conquest by the Europeans, since Columbus found it in Hayti, and the ancient Mexicans used it in their paintings, &c.

At present, indigo is very largely cultivated in Bengal, Madras, Bombay, Pondicherry, Java, and Manilla, in the East Indies; in the British West India islands, in Venezuela, and Guatemala, Hayti, Mexico, Carolina, and Louisiana, in America; and in Senegal, Egypt, and the Isle of Bourbon in Africa. The export from the East Indies is stated to amount to about 8,000,000 lb.

Tobacco (*Nicotiana tabacum*, *rusticum*, &c., natural order Solanaceæ).—The custom of smoking tobacco seems to have been widely extended in America at the time of the conquest; but it is not certainly known who introduced it into Europe, where it was first used as a medicine, but soon came into general use as a luxury, if not even a necessary of life. Smoking was punished as a crime in many countries of Europe when first introduced; but the use of tobacco, both for smoking and as snuff, prevailed over every obstacle, and spread itself to the extreme confines of the Old World, and it is now cultivated almost universally, since it thrives not only in the warmer, but even in temperate climates—as in France and North Germany; fiscal regulations being probably the only obstacle to its cultivation even in England.

Cinchona, or Peruvian Bark (*Cinchona spec.*, natural order Rubiaceæ).—These important medicinal plants grow upon the eastern declivities of the eastern Cordilleras of Peru, from 19° up to 5° south latitude, where the eastern chain of Peru ceases, and the inland plateau of the two chains is flattened out; here the Cinchonas are found also, on the eastern slope of the coast Cordilleras, from 6° south latitude to 3° north latitude. A third section of the distribution extends from 2° south latitude along the west slope of the coast Cordilleras, and from its bifurcation at 2° north latitude, on both slopes, to 6° north latitude. The fourth and most northern area spreads from the Magdalena river in the north-east direction, following the ramification of the Andes toward Venezuela, up to the coast of Caraccas—thus, from 2° to 11° north latitude. The Peruvian barks, beyond 11° north latitude, are not from *Cinchona*, but mostly from *Exostemma*.

The vertical limits of the Cinchona region lie between 6600 and 8300 feet under the equator—between 5000 and 7600 feet under 15° south latitude—but local influences enlarge these narrow boundaries very much. The horizontal diameter from east to west, determined by the angle of declination of the mountains, &c., never exceeds 2°, even in Bolivia, where it is greatest. Notwithstanding this wide area of distribution, the demand for cinchona bark is greater than the natural production, but its cultivation has not yet been attempted on a large scale. Nineteen species are distinguished by Weddell, the latest inquirer, from whom the above data are derived. The best kind, *C. Calisaya*, king's bark, Wedd. (13°–16° south latitude), is now becoming rare, and is frequently adulterated.

Mate, Paraguay Tea (*Ilex paraguensis*, natural order Ilicaceæ).—This is a species of holly, growing in the forests of Paraguay, Uraguay, Brazil, &c., the leaves of which are used, like tea, for preparing a beverage which is universally drank in the eastern states of South America. The leaf is 4 to 5 inches long, and is reduced to powder when dried, the infusion being taken through a tube having a bulb perforated with small holes.

Coca (*Erythroxylon Coca*, natural order Erythroxyleæ) is a shrub about 6 feet high, largely cultivated in Peru for the sake of its leaves, which are dried and used for mastication, like the betel leaf of the East Indies, in conjunction with unslaked lime, by the lower classes. It is a narcotic, but does not appear to possess nutritive properties. It was extensively used among the ancient Peruvians, and the use of it even formed part of the religion; the Indian miners still have a superstitious reverence for it.

Annatto (*Bixa orellana*, natural order Bixaceæ).—This substance is prepared from the red pulpy substance surrounding the seeds. In England and Holland, it is largely used for colouring cheese. The Spaniards use it for giving a rich tint to soups and chocolates.

Maguey, Pulque (*Agave sp.*, natural order Liliaceæ).—The juice of *Agave Americana*, and other species, is capable of being fermented, so as to yield an intoxicating drink, and is largely cultivated for this purpose in Central America.

Gutta Percha (*Isonandra gutta*, natural order Sapotaceæ).—This is the inspissated juice of a large tree growing in the Malay peninsula. Although only introduced scarcely ten years ago, it has become the object of extensive manufacture.

Cat (*Celastrus edulis*, natural order Celastraceæ).—The leaves of this plant are used by the Arabs for the stimulating properties.

Oil Palms (*Elais guineensis* and *E. melanococca*, natural order Palmaceæ).—Palm-oil, like that of the olive, is formed in the soft part of the fruit of the vegetable which yields it. It is obtained by boiling the fruits in water, and skimming off the oil which floats to the top. Within a few years, this substance—which is a kind of butter, rather than an oil—has become an object of enormously increased trade, from the inventions in the arts of bleaching and purifying fats having rendered it a most advantageous source of material for candles. In 1850, 448,589 cwt. were imported into Great Britain.

Gum Arabic (*Acacia vera*, *arabica*, and other species, natural order Leguminosæ).—The greater part of this substance is brought from the East Indies and Africa, especially Egypt, Marocco, and the south African colonies. Out of a little more than 33,000 cwt. imported into Great Britain in 1849, 16,000 came from Africa, and 13,000 from the East Indian empire.

Ginger (*Zingiber officinale*, natural order Zingiberaceæ).—This is the rhizome or subterranean root-stock of a plant cultivated in the tropical regions of Asia and America, and at Sierra Leone. The young shoots of the root-stock put forth in spring are the portions used for "preserved ginger," while the dry "ginger root" consists of the same parts a year old, taken up after the flower-stalks have died off.

Vanilla (*Vanilla planifolia* and other species, natural order Orchidaceæ).—The dried fragrant pods of several species of vanilla. It is imported into England from Mexico, Central America, and Brazil. The odour has been variously ascribed to the seeds, the seed-coat and the pulp, but most probably resides in the latter.

Capsicum Peppers (*Capsicum baccatum*, *annuum*, &c., natural order Solanaceæ).—The capsicum or Spanish peppers replace to a great extent, in the New World, the Piperaceæ of the East Indies.

Ipecacuanha (*Cephaelis Ipecacuanha*, natural order Rubiaceæ).—The root of this plant forms the well-known medicinal substance.

Opium (*Papaver somniferum*, and perhaps other species, natural order Papaveraceæ).—The milky juice of these plants, when dried, forms the well-known narcotic.

SMALL MAP—No. 3.—DISTRIBUTION OF TEA, SPICES, ETC.,

CHIEFLY CULTIVATED IN THE OLD WORLD.

Tea (*Thea viridis* and *Bohea*, natural order Ternstrœmiaceæ).—The teas are evergreen shrubs, growing about 6 feet high, and natives of districts not accurately ascertained, but lying between the limits of Eastern China and the river Brahmapootra, north-east of Calcutta, probably between 15° and 40° north latitude. The cultivation extends from the equator to 45° north latitude, but seems to be most successfully prosecuted between 25° and 33° north latitude, with a mean annual temperature of 64° to 72° Fahr. Almost all the tea of commerce is obtained from China, where, according to Mr Fortune, both species are grown, and both manufactured into green and black teas. The proper tea districts are the provinces of Fokien, Tschekiang, and Kiangnan (25° to 31° north latitude), in which *Th. viridis* is grown; and the teas exported to Europe are chiefly, if not exclusively, made from this. *Th. Bohea* is grown in the south of China, where *Th. viridis* will not thrive, and it yields tea of an inferior quality. The above principal districts lie between 115° and 122° east longitude; but tea is grown for home consumption in almost every province of China, as also in Japan, Tonquin, Cochin China, and some of the mountain districts of Ava. It has also been introduced into Java, Singapore, Malacca, and Penang, where it is grown on the hills; and its cultivation has been commenced in the British possessions on the continent of Asia, in Assam, and on the slopes of the Himalayas in the north and north-west provinces of India, where the prospects of success appear to be very good. Attempts have also been made to introduce the cultivation of tea into South America, but hitherto without success, since, although the quality was good, it was too expensive to allow of competition with China. Unsuccessful efforts have been made to introduce this plant into Algeria, but the climate is too hot there, while the trials made in Provence seem to indicate that tea might be grown in the south of Europe.

Tea was first brought to Europe by the Dutch in 1610, and to England in 1666. In 1830, the consumption of tea in England was estimated at 30,000,000 lb., while the whole of the rest of the civilised world used only 22,000,000 lb. In 1848, the annual consumption in Great Britain was estimated at from 40,000,000 lb. to 50,000,000 lb.

Pepper (*Piper nigrum*, natural order Piperaceæ).—Black pepper consists of the berries of a climbing perennial plant, which will grow only in very hot climates. The best pepper comes from the Malabar coast, which appears to be the native locality. It is now cultivated on the Coromandel coast, Pulo Penang, Siam, and the Malay peninsula, Java, Borneo, Sumatra, and other islands, and is one of the most important of East Indian exports. White pepper is the same substance, the husks of the berries being removed before grinding. Cayenne pepper is a totally different substance, obtained from a capsicum (*Capsicum annuum*). It is sometimes called Guinea pepper, and is cultivated largely in the tropical zone, in the Old and New Worlds.

Cinnamon (*Cinnamomum Zeylanicum*, natural order Lauraceæ).—The inner bark of a tree attaining a height of 20 or 30 feet, growing chiefly in Ceylon, of which island it is probably a native. It was transplanted by the English to Sumatra in 1798, and in 1825 carried to Java, Mauritius, and also to Brazil and the West Indies. Cinnamon plantations were also established on the coast of Coromandel, but they are now neglected. Ceylon furnishes most of the cinnamon of commerce, but the cultivation is increasing in Java. Cassia bark is the produce of *Cinnamomum Cassia*, and apparently of other species; it is found in the Eastern Archipelago, Philippines, and parts of the eastern coast of China.

Nutmeg (*Myristica moschata*, natural order Myristicaceæ) is the seed of a tree 30 feet high, now grown chiefly in the Banda Islands. The fruit is succulent, somewhat like a peach, and around the central stone or seed (the nutmeg) is found the scaly substance known as mace.

Cloves (*Caryophyllus aromaticus*, natural order Myrtaceæ).—Cloves are the dried buds of a tree 30 or 40 feet high, growing in the Moluccas, which appears to have been originally obtained from larger islands, but is cultivated almost exclusively in the little island of Amboyna. It does not succeed in Java. It has also been introduced into Mauritius and into Cayenne, but the cloves there produced are very inferior.

SECTIONS.

In these Sections, the Scales of Altitude are marked at the sides, while the Latitudes are indicated by figures under the base lines.

SECTIONS—Nos. 1 & 2.—ILLUSTRATIVE OF THE RELATIONS OF CLIMATE AND ALTITUDE, AS AFFECTING CULTIVATED VEGETATION IN EUROPE.

These two sections are drawn from south to north across Europe; in the west from Gibraltar (slightly curved eastward, so as to include France) to Iceland; and in Central Europe from Nice to North Cape. The limits of cultivation, defined by altitude, are remarkably regular in these sections.

SECTIONS—Nos. 3 & 4.—ILLUSTRATIVE OF THE GENERAL RELATIONS OF CLIMATE AND ALTITUDE, AS AFFECTING CULTIVATED VEGETATION IN THE OLD AND NEW WORLDS.

These are results of an attempt to lay down the regions of altitude of cultivation, so as to show their relations in the mountains of the Old and New World; but the data are so imperfect that these sections—at all events, that including Africa—could not be made to give more than very rough indications. It will be seen, however, that the lines depart very widely from the regularity assumed in Meyen's diagram.

ON THE DISTRIBUTION OF INDIGENOUS PLANTS CHARACTERISTIC OF THE DIFFERENT PARTS OF THE GLOBE.

THE general laws regulating the geographical distribution of plants have been indicated on the "Principles" prefixed to the account of the distribution of the plants yielding food and other useful substances; it will, therefore, be unnecessary to repeat them. But there are certain points requiring more particular consideration, in reference to the distribution of indigenous plants, to which attention must be drawn here. Bearing in mind the first *twelve* principles just referred to, we have now to enter into more details upon the subject of the last four of these (viz. 9—12), and to inquire into the characters of those plants which, by their distinct relation to certain physical conditions, become characteristic of particular regions. We have to ascertain what are the plants which will serve as indices of the peculiarities of climate dependent upon latitude, altitude, and similar conditions.

From what has already been stated, it will be understood that places at certain degrees of altitude, in a low latitude, correspond more or less evidently in the character of their vegetation, with others situated in the plains of higher latitudes, farther removed from the source of heat. From this it follows, that the kinds of plants characteristic of the temperate climates will be found more widely scattered over the surface of the globe, since they will occur on elevated tracts even in the tropics; but it must be remembered that the conditions under which these plants occur are not so favourable to vegetation generally, and that the plants of cooler climates are consequently fewer in number of species, and, in general, in quantity of individuals, than the plants characteristic of warm climates. Further, the plants found in different regions having corresponding or tolerably similar climates, are generally of distinct kinds, although nearly allied together, and are *representative species* or *genera*, belonging to distinct creations, suited to similar conditions, and therefore bearing general resemblance. We find these representations in all climates. The plants of the mountains of South America are quite distinct species, and, mostly, even genera, from those of Asia; the plants of the temperate part of North America are frequently of the same genera, but distinct species from those of Europe. The plants of the dry hot regions of Mexico (*Cacteæ*) are represented by plants of similar habit, but even of a different natural family (*Euphorbiaceæ*), in the similar climates of some parts of Africa.

Hence we have to adopt various modes of considering the geographical distribution of plants, to obtain a just idea of the way in which they occur upon the earth.

First, We may divide the surface of the globe into zones, according to latitude, and, again, the mountains of the various latitudes into vertical zones, or regions of altitude, corresponding to horizontal zones nearer the poles; then endeavour to ascertain the relative proportions of the natural families inhabiting these respectively. The attempts which have been made in this way, especially by Meyen, can only be regarded as rough approximations to the truth, since, as is seen by the isothermal lines and boundary lines of cultivated plants on the map No. 1., the lines of climate by no means run in the direction of the parallels of latitude, and the relations of *zones* of altitude are subject to great modification, according to the forms and local conditions of particular mountains or mountain chains. In our map we have modified Meyen's zones, by substituting for the parallels of latitude the annual isothermal lines (after Dove) corresponding pretty nearly to the average temperatures given by Meyen as belonging to his zones.

Secondly, Following Schouw, we may divide the surface of the globe into regions, indicating naturally circumscribed *floras*, or assemblages of more or less peculiar plants. If we entered into detail here, our subdivisions would become very numerous, since the local floras of almost all the natural basins of moderate extent exhibit peculiarities; but these small floras pass more or less gradually into the neighbouring assemblages. In Schouw's division of the globe, a small number of large and tolerably well-defined areas are marked; and these are calculated to afford much insight into the distribution of plants, when examined by those having some knowledge of botany.

Thirdly, We may examine the distribution of plants *physiognomically*. It is well known that certain plants are *social*, as it is termed—growing in vast quantities together, so as to give a peculiar aspect to the landscape. Such is the case, for example, with heaths—with the pines forming the northern forests, &c. Sometimes a number of species, all producing a vast quantity of individuals, belonging to a single genus of plants, occur as a preponderating feature of local vegetation; and sometimes a number of genera of one family, represented by one or more species, abound in individuals in certain localities. In this way certain species, genera, or even families, come to give the predominating character to the landscape, and form the chief peculiarities of its physiognomy. The investigation of the subject, in this point of view, is important, for the purpose of illustrating popularly and strikingly the local conditions of vegetation, and, moreover, demonstrates, in a very interesting manner, the *representation* which occurs among plants.

I. DIVISION OF THE HORIZONTAL RANGE OF VEGETATION INTO ZONES.

In the following descriptions, the names of the zones proposed by Meyen are adopted, but the boundaries are drawn according to annual isothermal lines.

1.—THE EQUATORIAL ZONE.

This zone, as limited by us, comprehends but a comparatively small range in the New World, and is most developed in the Old, especially in Africa. It will be observed, also, that the larger portion of it lies on the north side of the equator, since the preponderance of land in the northern hemisphere deflects the isothermal lines in this direction. The boundaries are the annual isotherms of 79°.3 Fahr. on each side of the equator; but it may be noticed that in Africa, as well as in Hindostan, and in the Indian Archipelago, there exist circumscribed regions between these lines, in which the annual isotherms rise to 81°.5 Fahr.

The characteristics of this zone are marked by the extreme luxuriance of vegetation, from the great heat together with the abundant moisture. The trunks of the trees attain enormous diameter; the flowers have most brilliant colours; and not only is the earth clothed most profusely with numberless forms of plants, but the trees are overgrown by Orchids, Aroids, Bromeliaceæ, and Ferns, and matted together by *lianes*, or gigantic rope-like woody climbers; so that the *primæval forests* present such a dense mass of vegetation as to be almost impenetrable, even to the explorer who advances axe in hand. The Palms, the Banana tribe (Musaceæ), arborescent Grasses, Pandanus, Scitamineæ and Orchideæ, are most striking features; the fig-trees of most varied kinds; the silk cotton-trees (Bombaceæ) also abound both in the Old and New Worlds; the Cæsalpiniæ, Malpighiaceæ, Anacardiæ, Swieteniæ, Anoneæ, Bertholletiæ, and Lecythideæ, especially mark the forests of America; the Sapindaceæ, Caryotæ, Artocarpi, Sterculiæ, Ebenaceæ, Meliaceæ, Laurineæ, &c., those of the Old World. In this zone also, in the Indian Archipelago, occurs the most remarkable of the Rhizanths, the gigantic parasite Rafflesia, with its flowers three feet in diameter, while, in America, this is almost rivalled by the Victoria water-lily, and the Aristolochias with their enormous helmet-like flowers—said, indeed, to be worn in sport as caps by the Indian boys.

Rich as the vegetation of this zone is in general, we find within the limits some of the poorest tracts upon the globe—namely, where water is wanting. The African desert and a portion of Arabia are the most striking examples, but the llanos of Venezuela are scarcely less parched and lifeless during the dry season, and in the rainy season present only grassy plains like the steppes of Central Asia. The poverty of these tracts is accounted for by their peculiar position, cutting them off from the influence of moist currents of air, their natural waterless condition being of course dependent on the geological changes which gave them their present configuration.

2.—THE TROPICAL ZONES.

These extend, in the north and south hemispheres, from the boundaries of the equatorial zone at the isotherms of 79°.3 Fahr. to the isotherms of 72°.5 Fahr. Taken altogether, the characteristics of these zones, as might be expected, are closely allied to those of the preceding. Rio de Janeiro and Canton are cited by Meyen as instances of this resemblance; Palms, Bananas, Canneæ, Meliaceæ, Anoneæ, and Sapindaceæ, prevail here, and Orchids, Pothos-like plants, and *lianes* abound. The Tree-ferns, the Pepper-plants, Melastomaceæ and Convolvulaceæ, however, become more prominent here, and serve as distinctive characters; and it is stated that, in these zones, the forests exhibit fewer parasites and more underwood. That portion of the western coast of South America lying within the south tropical zone, forms an exception to the general rule of luxuriance of vegetation, as does the inland tract of Africa bordering on the equatorial zone.

3.—THE SUB-TROPICAL ZONES.

These are bounded, on the equatorial side, by the annual isotherm of 72°.5 Fahr., and towards the poles by the isotherms of 68° Fahr. The countries lying within these enjoy the most delightful climates on the globe. Though the summer heat never rises to the intense heat of the torrid zone, it suffices to ripen most of the tropical fruits, while the winters are so mild that vegetation is never arrested. Palms and Bananas are still met with in the plains, and arborescent Grasses form a feature of the landscape, both in America and Asia; but the most striking character of these regions is formed by the abundance of forest-trees having broad, leathery, and shining leaves, such as the Magnolias and the Lauraceæ, and also of the plants of the Myrtle tribe.

4.—THE WARMER TEMPERATE ZONES.

Equatorial boundaries, the annual isotherms of 68° Fahr.; polar boundaries, the isotherms of 54°.5 Fahr. The general characteristics of these zones arise from the combination of the shining, leathery-leaved trees of the sub-tropical zones with the forest-trees which we find in our own country, such as oaks, beeches, &c.; the Palms vanish, but a number of handsome evergreen shrubs present themselves, and Heaths, Cisti, and showy Leguminous plants, are very abundant. The countries lying within these zones in different parts of the globe differ a good deal in their vegetation, and we may therefore enter into rather more detail here.

In the Mediterranean region, evergreen dicotyledonous trees with glossy leaves abound, showy shrubs, and many bright-coloured bulbous plants; Erica arborea, the bay, and the myrtle, are characteristic; the Turkey, holm, and cork oaks, the chestnut, the strawberry-tree, with the cherry laurel, laurustinus, and pomegranate are frequent, as are also the Phillyreæ, rosemary, oleander, &c.

The vine is a native of this zone, and is said to attain a diameter of 3 to 6 inches, and to climb to the top of the highest trees, in the forests of Mingrelia and Imeritia. The barren table-land of Asia falls in this zone, as does Japan, which has a rich vegetation. In America are found abundance of oaks and pines; Magnoliaceæ, such as the tulip-tree; a number of Leguminous trees, with thorny Smilax shrubs, and gigantic reeds: the Gleditschiæ on the banks of the Ohio are evergreen, with climbing Bignoniæ; evergreen trees here correspond to those of Southern Europe, intermingled in the forests with oaks, beeches, ash, and Platanus occidentalis.

In the southern hemisphere, this zone includes part of New Zealand and Australia, where again evergreen trees are intermixed with forest-trees with deciduous leaves; shrubby Ferns abound, and the Leguminosæ and Myrtaceæ are well represented.

In South America, the Pampas plains of Buenos Ayres fall in this zone, especially characterised by arborescent Grasses. Southern Chili represents the warm temperate vegetation, with its evergreen forests of Myrtaceæ, beeches, and Araucariæ; the Fuchsia is also characteristic of this region. The Chilian palm, like the dwarf palm of Southern Europe and the palmetto of North America, forms an outlier from the sub-tropical region.

5.—THE COOLER TEMPERATE ZONES.

Equatorial boundaries, the annual isotherms of 54°.5 Fahr.; the polar boundaries, the isotherms of 41° Fahr. The especial characteristics of these zones are the forests of deciduous trees with inconspicuous blossoms, intermingled with social Conifers, together with the Grass pastures. Here the trunks of the trees are overgrown only with Mosses and Lichens; the honeysuckle, the ivy, and the hop are the only important climbers, very different from the *lianes* of the tropics. Shrubs are pretty frequent, but they mostly lose their leaves in winter, such as roses, brambles, Viburna, &c. The social dwarf-grasses on good soil, with the sedges, cotton-grasses, and mosses, of wet ground, characterise the plains, and extensive heaths prevail in some districts. The contrast between summer and winter is strongly marked in the aspect of vegetable life; the trees are stripped of their leaves, the herbs die down to dwarf tufts, or hide themselves altogether in the ground, and the snow covers the surface of the plains in severe weather; but the warmth of summer, which brings out a lively and varied show of flowers, is sufficiently high to ripen the seeds of most, and thus annuals are more numerous than they are farther north.

This zone is not represented in Africa or in the South Sea. In South America, it includes Patagonia.

6.—THE SUB-ARCTIC ZONE.

Equatorial boundary, the annual isothermal line of 41° Fahr.; the polar boundary, the isotherm of 36°.5 Fahr. for the month of September. The southern boundary of this zone in the northern hemisphere corresponds pretty nearly to the limit of distribution of the oak in Europe and the east coast of North America, the northern boundary to the limit of the distribution of trees.

The striking characteristic of this zone is, indeed, the predominance of the Coniferous trees in the woods, giving place northward to the birch and alder, and generally alternating with willows where the soil is moist. Green pastures occur universally, especially adorned with showy flowering herbs in the spring and summer.

Nothing definite can be said concerning this zone in the southern hemisphere; Tierra del Fuego perhaps falls within it.

7.—THE ARCTIC ZONE.

The equatorial boundary is the isotherm of 36°.5 Fahr. for the month of September, or the polar limit of arborescent vegetation in the northern hemisphere; the polar boundary is the isotherm of 41° Fahr. for the month of July. The vegetation of this zone corresponds to what we understand commonly as Alpine shrubs, consisting chiefly of prostrate shrubs, with a peculiar tortuous and compacted habit of growth, such as the alpine Rhododendra, Andromedæ, the dwarf birch and alder, the bog-myrtle and dwarf willow, with a variety of low-growing perennial herbs, remarkable for the comparatively large size and bright colours of their flowers. Sedges and cotton-grasses occur socially, in some places cover extensive tracts; but the grassy pastures of the last zones are replaced to a great extent by tracts covered with Lichens.

8.—THE POLAR ZONE.

Equatorial boundary, the isotherm of 41° Fahr. for the month of July; polar limit, the isotherm of 36°.5 for the same month. This zone is characterised by presenting, in the four to six weeks of summer, an alpine vegetation devoid of even shrubs, and consisting of herbaceous perennials of dwarf habit, such as Saxifrages, Ranunculi, Pyrolæ, Potentillæ, Dryas, Draba, &c., and possessing, moreover, certain genera, such as Parrya, Phippsia, and others, which, although they extend into the arctic zone, are not met with in the alpine regions of the mountains of the more southern regions. In Spitzbergen, the number of Cryptogamic plants is remarkable, the Lichens alone equalling the Flowering plants, and predominating even in mass as well as number of species.

II. REGIONS OF ALTITUDE.

It is well known that the lofty mountains lying within the tropics exhibit a graduated variation of character in their vegetation, and that those which rise above the limit of eternal snow display more or less distinctly marked regions, representing the zones lying between the plains at the foot of such mountains, and the eternal ice of the polar zone.

Humboldt divided the surface of tropical mountains into three zones, representing the tropical, temperate, and frigid zones of the globe, and indicated the principal subdivisions of these regions. Meyen attempted to lay down a more systematic representation of the conditions in question, corresponding to his division of the earth's surface into zones. Great difficulty interposes here in any attempt at generalisation, since local conditions, arising from aspect, and conformation of surface, either giving more or less of precipitous character, accompanied by sudden changes, or producing elevated plains, &c., cause such great differences, even within the limits of single mountain systems, that no absolute rule can be applied. The rules laid down by Meyen apply pretty well to his zones within the limits of Europe, as is indicated by the lines of limits of Cereals in the Chart of the Distribution of Cultivated Plants; but, as the sections of the regions of altitude of greater extent demonstrate, great variation presents itself near the equator.

Still a generalisation of some kind, giving even approximative results, is of service, since it offers at least a temporary standard, which renders it easier to mark local peculiarities by specifying the deviation.

According to Meyen's views, the snow-line, beginning at the polar zone, rises between 1900 and 2000 feet above the level of the sea, and at the equatorial zone to 15,500 or 16,600 feet; and he divides the regions of altitude in accordance with this, raising each region between 1900 and 2000 feet in each zone, as he approaches the equator. Now, at North Cape, which lies near the polar limit of our sub-arctic zone, in Iceland, which is crossed by the same limit, the line of perpetual snow is about 2000 feet; we may therefore take this as the snow-line of our *arctic zone*. The equatorial limit of our sub-arctic zone falls in Southern Norway where the snow-line is about 4000 feet; while the equatorial limit of our cold temperate zone is not far removed from the Alps and Pyrenees, where the snow-line rises to 8000 feet and more. In the south of Spain, lying within the warm temperate region, snow lies in isolated patches below 11,000 feet. In the district of Sierra Nevada, which is one of the best known of the mountains of this zone, as regards vegetation, there is a sub-tropical region up to 600 feet; the true warm temperate vegetation extends up to about 4000 feet; a cold temperate vegetation from about 4000 to 6500. The vegetation then passes into a condition allied to the sub-arctic, but without trees, and characterised by shrubs of a similar nature to those of our arctic zone. This region extends to 8000 feet, and from thence to the summits of 11,000 feet there is an alpine summer vegetation (snow lying for eight months out of the twelve), which is again intermediate in character between those of our arctic and polar, consisting chiefly of perennial herbs like the latter, but presenting a formation of turfy pasture to some extent in the warm season. In the Caucasus the snow-line is much higher.

In the sub-tropical zone, on the Peak of Teneriffe, we find the vegetation of the warm temperate zone from about 2000 to 4000 feet; a representation of the cold temperate from 3000 to over 6000 feet; at about 8000 feet the climate is sub-arctic. This mountain does not reach the snow-line.

In Mexico, lying in our tropical zone, the lines are respectively shifted up in about the same ratio, as indicated in the diagram. We see throughout, then, a deviation from Meyen's ratio, in the tendency of the colder zones to widen out on the mountains of warmer zones; but this is partly owing to our dividing the zones according to temperature, and not according to latitude.

But if we attempt to lay down the conditions of the mountains of Asia under a similar point of view, we find greater deviations. The mass of elevated land in Central Asia modifies all the climatal conditions very much. The snow-line of the mountains of the cold-temperate and warm-temperate zones rise to 14,000 feet; that of the Himalayas to 18,000 feet in the northern parts. Our data scarcely suffice for the illustration of these modified conditions, and therefore we have confined ourselves to a set of regions founded upon the mountains of Europe, and Teneriffe, and the Andes of Mexico, for the tabular view of distribution in altitude given in the chart.

We now give a brief sketch of the characteristics of the different regions of altitude, as classified by Meyen; and to this is subjoined Meyen's hypothetical table, from his *Geography of Plants*. To show how far this diverges from the actual conditions, we have constructed a table showing the comparative altitudes of the characteristic forms of vegetation on a number of mountains where they have been carefully observed. The allocation of these mountains in the various zones is in accordance with our isothermal limitations, and not, as is the case with Meyen's limitation, according to parallels of latitude. The elevations are also merely given in round numbers.

1.—REGION OF PALMS AND BANANAS.

Corresponding to the equatorial zone, has been already characterised under that head. The Palms, Musaceæ, Canneæ, and Zingiberaceæ, are especially remarkable in its vegetation; the Palms gradually diminishing in numbers as the height increases, the Bananas becoming smaller, and the Scitamineæ vanishing. The Orchideæ and Aroideæ abound.

2.—REGION OF TREE-FERNS AND FIGS.

Corresponding to the tropical zone. The characteristic Tree-ferns are met with only where the climate is sufficiently humid. The genus Ficus is most prevalent in the elevated forests of the equatorial zone of the East Indies, giving them a remarkable character of gloomy grandeur and impervious density. In the New World, the Melastomaceæ belong to this region, predominating there in number of species, but they occur both as shrubs and trees in the East Indies.

3.—REGION OF LAURELS AND MYRTLES.

Corresponding to the sub-tropical zone. Here the Myrtaceæ, magnolias, camellias, and trees with shining leaves prevail; and the Proteaceæ, Eucalypti, Acaciæ, and heaths attain their maximum. In the tropics of the New World, this region abounds in the genera Melastoma, Liquid amber, Styrax, Eugenia, and Inga, and certain Conifers.

4.—REGION OF EVERGREEN TREES.

Corresponding to the warm temperate zone. This region is characterised by a vegetation analogous to that of the South of Europe, exhibiting large trees with evergreen leaves, partly consisting of laurels, with Ilex, Arbutus, olives, Ardisiæ, &c. This region is greatly developed on the lower inclines of the mountains of the zone to which it corresponds, as on the hills of the Mediterranean basin, of Asia Minor, Armenia, and the Caucasus, and also in the warmer temperate zone of North America.

5.—REGION OF DECIDUOUS TREES.

Corresponding to the cold temperate zone, and therefore exhibiting a predominance of trees such as our beech and oak; but this region seems to be absent from the mountains in many parts of the tropical and equatorial zones, since the tree limit is carried down by peculiarities of climate, which, on the other hand, favour the advance of more southern forms into the upper regions. In Java and Sumatra, stunted trees of the class belonging here replace the dwarf Conifers of European mountains, and form the tree limit far below the altitude at which forests of tall Conifers occur in the more northern Himalayas—a condition explained in some degree by the local circumstances of the equatorial mountains, which are deficient of the supplies of moisture furnished by the vast masses of snow resting perpetually upon the Himalayas.

6.—REGION OF CONIFERS.

Corresponding to the sub-arctic zone. This zone, characterised by the growth of pines and firs, is well represented on most mountains, with the exception of the Peruvian Cordilleras, where the Escallonieæ are said to be substituted for them. But the Conifers do not always form the uppermost belt of trees, even when they flourish in a well-defined region. Thus the region of the Conifers, in a general sense, which reaches to the tree-limit with pines in the Alps, Pyrenees, and the Andes of Mexico, includes, in the Scandinavian mountains, in the Himalayas, and the Caucasus, a region of birches, which rise out of it, to form the last representatives of arboreal vegetation.

7.—REGION OF ALPINE SHRUBS OR OF RHODODENDRA.

This region, corresponding to the arctic zone, is characterised on the north and central European mountains especially, by shrubby Rhododendra, dwarf willows, the dwarf birch and alder, and other analogous plants. Similar plants prevail also in the Caucasus, with species of juniper. In the Himalayas, dwarf willows, junipers, and species of Ribes or currant seem to represent the vegetation of this region; while, on the Andes of Quito, the genus Befaria appears to correspond in its geographical development to the Rhododendra of the north.

8.—REGION OF ALPINE HERBS.

Corresponding to the polar zone, usually presenting only patches of vegetation scattered over a broken surface of ground, covered during the greater part of the year with snow, and exhibiting accumulations in all seasons in sheltered spots. Lichens abound here; Lecidea geographica has been found in most diverse localities, where bare rock rises above the ground, forming generally the last trace of vegetation. The plants of this region are remarkable in many respects, in none more than the beauty and comparatively large size that usually characterises their flowers. They are mostly of perennial growth, since, although the severe cold prevailing throughout the greater part of the year is unfavourable to the maturation and preservation of seeds, the thick covering of snow protects established plants from the severe frost; and it is known that they are arrested in warmer regions where winter frosts prevail without great accumulations of snow, precisely because they are then incapable of bearing the cold to which they are directly exposed.

Meyen's Comparative Exhibition of the Different Zones, with the Corresponding Regions.

The elevations and temperatures are here given in round numbers.

Distance of the Regions from the Plain.	Names of the Zones.	Equatorial.	Tropical.	Sub-Tropical.	Warm Temperate.	Cold Temperate.	Sub-Arctic.	Arctic.	Polar.	Distance from the Snow Line.	Mean Annual Temperature of the Regions (by Fahr. Scale).
	Area of the Zones.	Lat. 0°—15°	15°—23°	23°—34°	34°—45°	45°—58°	58°—66°	66°—72°	72°—82°		
	Mean Heat (in deg. Fahr.)	79°—86°	73½°—79°	64½°—79°	54°—57°	43°—54°	39°—43°	32°—29¼°	29¼° and under.		
16,000		16,000	14,000	12,000	10,000	8,000	6,000	4,000	2,000		
14,000	Region of Alpine Herbs,		12,000	10,000	8,000	6,000	4,000	2,000		2,000	37½°—39½°
12,000	Region of Rhododendra,		10,000	8,000	6,000	4,000	2,000		..	4,000	44½°
10,000	Region of Conifers,		8,000	6,000	4,000	2,000		..	..	6,000	52°
8,000	Region of Deciduous Dicotyledonous Trees,		6,000	4,000	2,000		..	..	..	8,000	57°
6,000	Region of Evergreen Dicotyledonous Trees,		4,000	2,000		..	..	..	..	10,000	63°
4,000	Region of Myrtles and Laurels,		2,000		..	..	..	..	..	12,000	68°—70°
2,000	Region of Tree-Ferns and Figs,			..	..	..	..	..	..	14,000	72°—77°
0	Region of Palms and Bananas,		..	..	..	..	..	..	..	16,000	81°—86°

COMPARATIVE VIEW OF THE ELEVATIONS OF REGIONS OF ALTITUDE IN THE ISOTHERMAL ZONES.

(The figures in the squares opposite the names of the respective regions indicate the elevation at which they commence).

Names of Zones.	Equatorial Zone.	Tropical Zone.		Sub-Tropical Zone.		Warm Temperate Zone.							Cold Temperate Zone.	Sub-Arctic Zone.		Arctic Zone.
Temperature of Zones.	81°5' to 79°2' Ann. Mean.	79°2' to 73°5' Ann. Mean.		72°5' to 68° Ann. Mean.		67°5' to 54°5' Annual Mean.							54°5' to 41° Annual Mean.	41° Ann. Mean to 36° Mean of Sept.		36° Mean of Sept. to 41° Mean of July.
Names of Mountains.	Java and Sumatra.	Andes of Mexico.	Andes of Peru.	Teneriffe.	Himalayas.	Rocky Mountains, N. America.	Sierra Nevada, Spain.	Lycian Taurus.	Pontic Chain of Lazistan.	Ararat.	Inner Armenia.	Alatau, Soongarei.	Swiss Alps.	Norway.	Kamtschatka.	Iceland.
Snow Line.	0.	15,500.	15,300.	0.	15,800—18,000.	11,500.	0.	0.	10,000.	13,500.	11,000.	10,700.	8,500.	4000—5000.	5000.	2,000.
Alpine Herbs.	9000 Viola, Ranunculus, Myrica, Erica.	13,000	Primulaceæ, Ranunculaceæ, Rosaceæ, &c. Berberis.	10,400	Papaveraceæ, Cruciferæ, Primulaceæ, &c.		11,000 Alpine Herbs and Shrubs.	10,000 Alpine Herbs and Shrubs.	8,000			Lichens. 8,000	7,000	3300—2800	Saxifraga. 2,700	1,000
Alpine Shrubs (Rhododendra, &c.)	7000	Stevia. 13,000	Befaria. 10,400	9,000	Salix, Spiræa, Juniperus, Lonicera. 14,100	11,000	7,000	8,000	Rhododendron caucasicum. 5,700	8,000	5,000	Juniperus. 7,500	6,000	Dwarf Birch, Willow, 2000—3000	Alnus incana, Rhododendra. 2,000	Alpine Shrubs.
Limit of Trees.																
Coniferæ and Birches.	Podocarpus.	Abies religiosa, &c. 8000	Escallonia 8000	Juniperus Oxycedrus. 6000 Spartium.	Abies, Pinus.	Pinus.	Pinus sylvestris, 4,000	Juniperus excelsa, 6000			4,500	Pinus.	Conifers. 4,000	Birch. 1,000 Conifers. 2,000	Alnus fruticosa Sorbus. Coniferæ. 500	64° N. L.
Deciduous Forest Trees (Oak and Beech).		Quercus. 6000		Pinus canariensis. 4000	Quercus. 10,000		Quercus toza, Pinus Pinaster. 2,000	Platanus. 3,000 Oak Woods. 1,500	Beech, with Firs. 4,000		Beech. 1,000		Beech and Oak. 2,000 Chestnut.	67° N. L.	60° N. L.	
Evergreen Forest Trees.	Ternstrœmiaceæ. 6000	Melastomaceæ, Yucca, Bambusa.		Ardisia, Laurus. 2500 Olea, Myrica.	Magnolia, Castanea. 7000 Ardisia. 6000		Olive, Cork, Pomegranate. 600 (Opuntia, Cotton, Sugar Cane.)	Evergreen Trees and Shrubs.	Evergreen Shrubs.		Olea, Laurus, Buxus, Planera.		46°—47° N. L.			
Lauraceæ and Myrtaceæ.	Dipterocarpeæ. 4000	Jatropha, Chamædorea, Malpighiaceæ, &c.	Cacti, Eugenia 5000 Cinchonæ, Melastomaceæ.	1200 Arborescent Euphorbiæ, Dracæna, Pinus Sycamorus.	Celastrus, Gambelia, Myrsine. 2000	39° N. L.	37° N. L.	37° N. L.	41° N. L.	40° N. L.	37° N. L.	44°—46° N. L.				
Tree Ferns and Figs.	Forests of Liquidambar. 3000	Tropical Forests. 3000	Tree-Ferns, &c. 3000	Bananas, Saccharum, Palms.	Tree-Ferns, Figs, Palms.											
Palms and Bananas.	Palms, Scitamineæ, Deep Equatorial Forests.	Bombax, Palms, Mimoseæ.	Palms, Scitamineæ.	28° N. L.	28°—30° N. L.											
	0°—10° N. L.	19° N. L.	0°.													

On comparing the accompanying tables, by noticing the latitudes given in the second at the foot of the columns, it will be seen that the location of the mountains in the various zones differs only in the hotter and colder of the latter; those of the warm temperate, cold temperate, and sub-arctic (except in the case of Iceland) being similarly arranged in both. The great discrepancies existing between mountains occurring in the same zone, indicate that local circumstances must have most powerful influence in determining the altitudes attained by the various classes of vegetation. We are not in a position to give the real temperatures of regions of altitude with any accuracy in most cases, or these would probably greatly assist in ascertaining the direct causes of aberration; for differences of temperature certainly accompany the difference of elevation attained by particular forms of plants. Good examples of the influence of the form and local conditions of mountains are furnished by Teneriffe, Ararat, the Himalayas, and the Rocky Mountains of North America. The first is an isolated mountain, exposed to the equalising influence of the ocean; the second an isolated mountain situated in the interior of a continent; the two chains are portions of enormous systems of mountains extending over large regions in the interior of continents. To work out this subject thoroughly, however, it is necessary to observe not only the conditions of different mountains, but those of the different declivities of the same mountain; since, when great elevations are attained, chains of mountains form the boundaries of local climates, and present different conditions on the two faces.

III. SECTIONS OF MOUNTAINS.

In the pictorial representation of the distribution of plants in a perpendicular direction, each group is placed at its natural elevation, so as to exhibit, in a striking manner, the variety of forms met with in proceeding from the foot to the summit; that is, in the equatorial zone, from the regions of Palms and Ferns to that of the Alpine herbs, Grasses and Lichens. The names of the families are placed at the upper, and sometimes also at the lower limit of their occurrence, the scale of English feet accompanying the diagrams indicating the elevation. The designs relating to the Alps, Pyrenees, and Lapland, have been extended from Humboldt's *Elements of Botanical Geography*. Names of cities and other places at considerable elevations, as also the highest points reached by some of the most enterprising naturalists, are engraved in a lighter character, to distinguish them from those of plants.

The snow-line and limits of vegetation of the Andes of Bolivia are laid down from Pentland's observations; the volcano of Aconcagua from the measurements of Pentland and Fitzroy, who have ascertained its real elevation. Monte Rosa has been added to the diagram of the Alps.

The diagram of the Himalayas has been revised, with reference to the results of the investigations of recent naturalists, especially Dr Hooker, with Dr Thompson, M. Jacquemont, &c.

Teneriffe and the Himalayas form the transition from the torrid to the temperate zone, but differ much in their characters.

The Alps and the Pyrenees belong to the temperate zone. In ascending the Alps, we leave the vineyards and a rich vegetation at the foot, more particularly on the south side, and pass through a region where the walnut and chestnut thrive, into others where the oak, beech, and birch successively become arrested by the severity of the climate; the oak at about 2600 feet, the beech at about 3200; and beyond these the forests are formed almost exclusively of Coniferous trees—the spruce-fir, the larch, and the Scotch-fir, these occurring successively in the arborescent vegetation, passing, at about 6000 feet, by the dwarf fir (*Pinus Cembra*) into the shrubby growth of Rhododendra or alpine roses. Beyond these occur the alpine herbs—little perennial plants scarcely rising above the surface of the ground, but bearing remarkably large and brightly-coloured flowers in the short summer period, when they are left bare by the melting of the snow. The stony surface of the ground, bordering on the region where the snow never melts, is clothed with Lichens and a few Mosses, varying by their stain-like patches the monotonous colour of the rock.

In the mountain systems of all latitudes, and in all parts of the globe, the highest region of vegetation, when bounded by the line of eternal snow, presents a physiognomy similar to that of the Alps; but when the snow-line is not nearly attained, as in Java and Sumatra, and other mountains with summits unprovided with a perennial source of moisture, the upper region of vegetation departs from the true alpine character, and the plants of the regions to which the height corresponds, form a representation of the alpine condition, by assuming a stunted and unhealthy aspect under the influence of the dry and otherwise unfavourable climate.

SECTIONAL DIAGRAM ILLUSTRATING THE COMPARATIVE ELEVATION OF THE REGIONS OF ALTITUDE ON SOME OF THE MOUNTAINS OF THE NORTHERN HEMISPHERE.

This sketch is given to serve as an illustration of some of the points dwelt upon in the descriptions of the regions of altitude. The zones are here divided by isothermal lines, as in the chart, and indicated by the numbers at the top of the dotted lines; a scale of ⅒th of an inch to 1000 feet presents the means of ascertaining the exact height of the regions, which are given in approximations or averages.

IV. DIVISION OF THE GLOBE INTO PHYTO-GEOGRAPHIC REGIONS ACCORDING TO SCHOUW.

PRINCIPLES ON WHICH THE DIVISIONS ARE FOUNDED.

1. At least one half of the known species of plants of the tract constituting a botanical region are peculiar to it.
2. A fourth part of the genera of the region are either peculiar to it, or have so decided a maximum that they are comparatively rare in other regions.
3. The individual families of plants are either peculiar to the region or have a decided maximum there.

In our map the regions are so coloured that those of the same tint possess a certain analogy to each other, and may be considered as *representatives*, containing different genera or families, but occurring under somewhat similar external conditions.

The figures on the chart obviate the necessity of stating the geographical boundaries of the regions, which are seen by simple inspection.

1. REGION OF MOSSES AND SAXIFRAGES (ARCTIC ALPINE OR WAHLENBERG'S REGION).

Mean temperature.—Polar regions, 2°—41° Fahr. Mountains in the south, 21°—37° Fahr.

Character.—Characteristic and predominant genera—Ranunculus, Arabis, Draba, Arenaria, Dryas, Potentilla, Saxifraga, Rhododendron, Azalea, Gentiana, Pedicularis, Salix, Musci, Lichenes. Of the polar countries especially—Coptis, Eutrema, Parrya, Diapensia, Andromeda, Ledum. Of the mountain regions—Cherleria, Campanula, Phyteuma, Primula, Aretia, Soldanella. Dwarf perennial herbs with comparatively large flowers of bright colours. Trees absent.

Predominant shrubs and half-shrubs of the polar countries.—Betula nana, Salix lanata, S. fusca, S. lapponicum, S. reticulata, S. arctica, S. herbacea, Rubus chamæmorus, Empetrum nigrum, Andromeda hypnoides, A. tetragona, Arbutus alpina, A. uva ursi, Azalea procumbens, Rhododendron lapponicum, Menziesia cærulea.

Predominant shrubs and half-shrubs of the mountains.—Juniperus nana, Alnus viridis, Salix reticulata, Salix herbacea, Rhododendron ferrugineum, R. hirsutum, R. caucasicum, Vaccinium Myrtillus, U. uliginosum, Azalea procumbens, Arbutus alpina, A. uva ursi, Empetrum nigrum.

Plants which approach very closely to the snow-line.—Ranunculus glacialis, Saxifraga oppositifolia, Silene acaulis; in the polar countries especially, Agrostis algida, Ranunculus hyperboreus, R. nivalis, Saxifraga rivularis, S. cernua, S. nivalis, Papaver nudicaule, Draba alpina, Lychnis apetala, Diapensia lapponica. In the mountain regions, Saxifraga muscoides, S. bryoides, Cherleria sedoides, Aretia helvetica, A. alpina, Draba nivalis, Petrocallis pyrenaica, Arabis bellidifolia, Myosotis nana, Gentiana nivalis, Achillea nana, Linaria alpina. No cultivation in this region.

2.—REGION OF UMBELLIFERÆ (NORTH EUROPEAN AND NORTH ASIATIC, OR LINNÆUS'S REGION).

Mean temperature, 29°—46° Fahr.

Character.—Umbelliferæ, Cruciferæ, Coniferæ, Amentaceæ, Gramineæ, Cariceæ, Fungi, Cichoraceæ, Cynarocephalæ; in Asia, more particularly, Saline plants (such as Salsola and Salicornia) and Astragaleæ. Luxuriant pasture; forest trees with deciduous leaves; a few heaths.

Predominant trees and shrubs.—Pinus sylvestris, P. Cembra, P. sibirica, Abies excelsa, A. pectinata, Larix europea, Juniperus communis, Betula alba, Alnus glutinosa, A. incana, Fagus sylvatica, Quercus pedunculata, Q. sessiliflora, Carpinus Betulus, Castanea vesca, Salices, Populus tremula, Corylus Avellana, Ulmus campestris, Calluna vulgaris, Prunus spinosa, Pyrus Aucuparia, Acer pseudo-platanus, A. platanoides, A. campestre, Tilia platyphylla, T. microphylla.

Cultivated plants.—Cereals: rye, barley, oats, wheat, spelt, maize, millet (Panicum miliaceum) buckwheat, potato.

Fruits.—Apple, pear, quince, cherries, plums, apricot, peach, mulberry, walnut, grape, currant, gooseberry, strawberry, melons.

Esculent vegetables.—Cabbage, rape, turnip, radish, mustard, pease, beans, lentils, spinach, beet, cucumber, gourd, carrot.

Fodder plants, &c.—Clovers, vetches, lucerne, rye-grass;—hops, flax, hemp, tobacco.

3.—REGION OF THE LABIATÆ AND CARYOPHYLLEÆ (MEDITERRANEAN OR DECANDOLLE'S REGION).

Mean Temperature, 55°—73° Fahr.

Character.—Labiatæ, Caryophylleæ, Boragineæ, Cistineæ, Liliaceæ, the families cited in the preceding region, but mostly less prevalent, especially the Cariceæ. Representatives of tropical families—Palmæ, Terebinthaceæ, Lauraceæ; families which increase towards the equator becoming more numerous, Leguminosæ, Malvaceæ, Solanaceæ, Euphorbiaceæ, Urticaceæ.

Genera.—Adonis, Nigella, Trifolium, Medicago, Genista, Cytisus, Scabiosa, Anthemis, Achillea, Verbascum, Narcissus; many evergreen trees and shrubs; a greater number of woody plants than in the second region; pasture less luxuriant; a winter flora existing.

Predominant trees and shrubs.—Pinus Pinea, P. Pinaster, P. halepensis, P. Laricio, Cupressus sempervirens, Juniperus phœnicea, J. macrocarpa, Quercus Cerris, Q. pedunculata, Q. sessiliflora, Q. Ilex, Q. Suber, Q. Ægilops, Q. coccifera, Q. infectoria, Castanea vesca, Platanus orientalis, Alnus cordifolia, Corylus Colurna, Ostrya vulgaris, Acer monspessulanum, A. neapolitanum, Pistacia Lentiscus, P. terebinthus, Ceratonia siliqua, Cercis siliquastrum, Genista scoparia, Mespilus pyracantha, Prunus lauro-cerasus, Tamarix gallica, T. africana, Myrtus communis, Punica granatum, Opuntia vulgaris, Viburnum Tinus, Arbutus Unedo, Erica arborea, E. scoparia, Rhododendron ponticum, R. maximum, Cisti, Phillyrea latifolia, P. angustifolia, Ornus europea, O. rotundifolia, Nerium Oleander, Rosmarinus officinalis, Ephedra distachya, Chamærops humilis, Ruscus aculeatus, Smilax aspera, Tamus communis, Agave americana. (The highest parts of the mountains here belong to the first region, the middle elevations to the second region.)

Cultivated plants.—The same as in the preceding region, only the following are more rare, or only seen on the mountains: rye, currants, gooseberry, buckwheat, and hop; while the following are added:—

Cereals.—Rice, millets (Sorghum vulgare, Panicum italicum).

Fruit.—Figs, almond, Pistachio nut, lemon, citron, sweet and Seville oranges, prickly fig (Opuntia), water-melon, olive.

Esculents, &c.—Melongena, tomato, anise, coriander; cotton, white mulberry, saffron, sumach, lupins, saintfoin.

(*Note.*—Madeira, the Azores, and Canaries, belong to this region, but their floras approach that of North Africa.

Characteristic forms.—Sempervivum arboreum, S. canariense, S. tortuosum, &c., Ilex Perado, Pleroma pendula, Cacalia Kleinia, Sonchus fruticosus, Arbutus callicarpa, Ardisia excelsa, Ceropegia aphylla, Echium giganteum, &c., Laurus fœtens, Euphorbia balsamifera, E. canariensis, Myrica Faya, Pinus canariensis.)

4.—REGION OF ASTEREÆ AND SOLIDAGINÆ (NORTHERN NORTH AMERICAN, OR MICHAUX'S REGION).

Mean temperature, 9°—59° Fahr.

Character.—More species of Coniferæ and Amentaceæ than in II., but fewer Umbelliferæ, Cruciferæ, Cichoraceæ, and Cynarocephalæ.

Genera.—Hydrastis, Sanguinaria, Hudsonia, Ptelea, Robinia, Gymnocladus, Purshia, Gillenia, Decodon, Œnothera, Clarkia, Ludwigia, Bartonia, Claytonia, Heuchera, Itea, Hamamelis, Mitchella, Aster, Solidago, Liatris, Rudbeckia, Galardia, Vaccinium, Andromeda, Kalmia, Sabbatia, Houstonia, Hydrophyllum, Phlox, Monarda, Dodecatheon, Dirca, Hamiltonia, Lewisia, Trillium, Medeola.

Predominant trees and shrubs.—Pinus Strobus, P. inops, P. resinosa, P. banksiana, P. variabilis, P. rigida, P. serotina, P. pungens, Abies balsamea, A. taxifolia, A. canadensis, A. nigra, A. rubra, A. alba, Larix pendula, L. macrocarpa, Thuja occidentalis, T. sphæroidea, Juniperus virginiana, J. sabina, Taxus canadensis, Quercus, 25 sp., Fagus sylvatica, F. ferruginea, Castanea americana, C. pumila, Ostrya virginica, Carpinus americana, Corylus americana, C. rostrata, Alnus glutinosa, A. crispa, A. serrulata, Betula nigra, B. papyracea, &c., Salix, 27 sp., Populus balsamifera, P. monilifera, &c., Myrica cerifera, &c., Platanus occidentalis, Liquidamber styraciflua, Juglans nigra, J. cinerea, &c., Ulmus americana, &c., Nyssa aquatica, Fraxinus alba, F. nigra, &c., Ornus americana, Ribes floridum, R. aureum, &c., Vaccinium, 20 sp., Andromeda, 10 sp., Kalmia latifolia, K. angustifolia, K. glauca, Azalea viscosa, A. nitida, A. glauca, A. nudiflora, &c., Rhododendron maximum, Cornus florida, C. alba, C. canadensis, &c., Hamamelis virginiensis, Spiræa salicifolia, S. chamædrifolia, S. opulifolia, S. hypericifolia, &c., Gillenia trifoliata, Cratægus sp., Cerasus pumila, C. nigra, &c., Purshia tridentata, Rubus, 20 sp., Pyrus sp., Robinia Pseud-acacia, R. hispida, Gymnocladus canadensis, Rhus typhina, R. glabra, R. venenata, R. Toxicodendron, &c., Ptelea trifoliata, Ceanothus americanus, &c., Rhamnus alnifolius, &c., Ilex opaca, &c., Euonymus americanus, E. atropurpureus, Staphylea trifolia, Ampelopsis hederacea, Acer rubrum, A. dasycarpum, A. saccharinum, A. striatum, Negundo fraxinifolium, Zanthoxylum fraxineum, Z. tricarpum, Tilia glabra, T. pubescens, Liriodendron tulipifera.

In the northern parts (to 50°—55° N. L.) cultivation precarious. South of this the same plants as those cultivated on the second region, but maize more extensively.

5.—REGION OF MAGNOLIÆ (SOUTHERN NORTH AMERICA, OR PURSH'S REGION).

Mean temperature, 59°—73° Fahr.

Character.—A certain approximation to the tropical vegetation; Canneæ (Canna, Thalia), Palmæ (Chamærops), Yucca, Cycadeæ (Zamia), Laurus, Ipomœa, Bignonia, Asclepias, Cacteæ (Mammillaria, Opuntia), Rhexia, Passiflora, Cassia, Sapindus.

Few Labiatæ, Caryophylleæ, Umbelliferæ, Cichoraceæ, Geranieæ; few species of Aster or Solidago.

Trees with broad shining leaves and large flowers.

Genera.—Magnolia, Liriodendron, Illicium, Asimina, Dionæa, Pavia, Amorpha, Gleditschia, Baptisia, Petalostemon, Calycanthus, Œnothera, Claytonia, Rudbeckia, Liatris, Silphium, Kalmia, Houstonia, Frasera, Halesia, Dodecatheon.

Predominant trees and shrubs.—Magnolia grandiflora, M. glauca, &c., Illicium floridanum, I. parviflorum, Liriodendron tulipifera, Asimina, sp., Pavia flava, P. macrostachya, &c., Amorpha fruticosa, &c., Gleditschia triacanthos, &c., Robinia viscosa, Cassia tora, C. marilandica, &c., Acacia glandulosa, Calycanthus floridus, &c., Kalmia hirsuta, K. cuneata, Opuntia vulgaris, O. fragilis, O. missouriensis, Halesia tetraptera, H. diptera, Laurus Catesbyana, L. carolinensis, L. Benzoin, L. Sassafras, &c., Juglans fraxinifolia, Carya aquatica, C. myristiciformis, Liquidamber styraciflua, Carpinus americanus, Castanea americana, C. pumila, Platanus occidentalis, Quercus, 25 sp., Taxodium distichum, Pinus tæda, P. palustris, Zamia integrifolia, Yucca gloriosa, Y. aloifolia, &c., Chamærops Hystrix, C. Palmetto, C. serrulata.

Cultivated plants.—About the same as in the third region, with the exception of the olive. Cultivation of rice more extensive. In the southern parts some tropical plants, especially the sugar-cane.

6.—REGION OF CAMELLIÆ AND CELASTRINÆ (CHINESE, JAPANESE, OR KÆMPFER'S REGION).

Mean temperature, 54°—68° Fahr.

Character.—

Genera.—Magnolia, Nandina, Eurya, Camellia, Thea, Celastrus, Ilex, Euonymus, Bumalda, Hovenia, Kerria, Spiræa, Gonocarpus, Lagerstrœmia, Aucuba, Bladhia, Dœrnea, Eleagnus, Polygonum, Pollia.

Predominant trees and shrubs.—Rhapis flabelliformis, Pinus sinensis, &c., Cunninghamia lanceolata, &c., Taxus nucifera, T. verticillata, Salisburia adiantifolia, Cryptomeria japonica, Cupressus pendula, Juniperus virginiana, Thuja orientalis, T. dolabrata, Quercus glabra, Q. glauca, Alnus japonica, Juglans nigra, Broussonetia papyrifera, Daphne odora, Laurus glauca, L. lucida, L. umbellata, L. pedunculata, Olea fragrans, Diospyros kaki, Mespilus japonica, Sophora japonica, Acer japonicum, A. septemlobatum, A. palmatum, &c., Camellia japonica, C. sasanqua.

Cultivated plants.—Rice, wheat, barley, oats, doura (Sorghum vulgare), millet (Eleusine coracana), buckwheat, sago (Cycas revoluta), tarro (Arum or Caladium esculentum), batatas, or sweet potato; various species of pear, apple, crab, &c., quince, plum, apricot, peach, medlar; many species of citrus (oranges, shaddocks, &c.), melons.

Tea, rapes (Brassica sinensis), radish, cucumber, cocomoo, gourds, water-melon, anise, star-anise, soja, Nelumbium, Trapa, Scirpus tuberosus, Convolvulus reptans, beans, pease, Solanum æthiopicum, sesamum, hemp, paper mulberry, cotton, indigo, Isatis indigotica, Urtica nivea.

7.—REGION OF THE SCITAMINEÆ (INDIAN, OR ROXBURGH'S REGION).

Mean temperature, 66°—83° Fahr.

Character.—The tropical families make their appearance, or become more abundant: Palmæ, Cycadeæ, Scitamineæ, Aroideæ, Artocarpeæ, Urticeæ, Euphorbiaceæ, Lauraceæ, Convolvulaceæ, Bignoniaceæ, Apocyneæ, Rubiaceæ, Leguminosæ, Terebinthaceæ, Meliaceæ, Guttiferæ, Sapindaceæ, Byttneriaceæ, Malvaceæ.

The extra-tropical vanish, or only present themselves sparingly: Cariceæ, Coniferæ, Amentaceæ, Labiatæ, Boragineæ, Compositæ, Rosaceæ, Caryophylleæ, Cistaceæ, Cruciferæ, Ranunculaceæ.

Genera.—Uvaria, Grewia, Eriolæna, Garcinia, Buchanania, Crotalaria, Flemingia, Butea, Carpopogon, Jambosa, Gratiola, Tectona, Holmskioldia, Ficus, Phytocrene, Calamus.

The trees are never without leaves. The number of arborescent plants is greater than outside the tropics. Large and splendid flowers. Many climbing, parasitical, and epiphytic plants.

Predominant arborescent plants.—Dillenia ornata, D. scabrella, Uvaria, sp., Michelia Campaca, &c., Bombax insignis, &c., Sterculia, sp., Astrapæa Wallichii, Elæocarpus, sp., Calophyllum, sp., Garcinia, sp., Sapindus, sp., Swietenia febrifuga, Cissus, sp., Aquilaria malaccensis, Semecarpus Anacardium, Melanorrhœa usitata, Mimosa, sp., Acacia, sp., Amherstia nobilis, Pterocarpus santalinus, Cassia fistula, Jambosa, sp., Gardenia, sp., Nauclea, sp., Uncaria Gambir, Diospyros ebenum, &c., Urceola elastica, Bignonia, sp., Avicennia tomentosa, Tectona grandis, T. Hamiltoniana, Laurus Cassia, L. Cinnamomum, L. malabatrum, Tetranthera, sp., Myristica, sp., Hernandia sonora, Ficus religiosa, F. indica, F. elastica, F. benjamina, and many others; Cycas revoluta, Borassus flabelliformis, Cocos nucifera, Elate sylvestris, Metroxylon sagus, Calamus rotang, C. rudentum, C. draco, &c., Areca catechu, Taliera bengalensis, Dracæna draco, Pandanus odoratissimus, Flagellaria indica, Bambusa arundinacea.

Cultivated plants.—Rice, millets, &c. (Panicum frumentaceum, Eleusine coracana, Sorghum, sp.), sago (Cycas circinalis), yams, ground-nut (Arachis), cocoa-nut, tamarind, mango, mangosteen, banana, plantain, rose-apple (Eugenia, Jambosa), guava, oranges of various kinds, shaddock, water-melon, sugar, coffee, cloves, pepper, ginger, cardamums, turmeric, cotton, indigo, &c., soja, beans, pulses (Dolichos, sp).

8.—REGION OF RHODODENDRON TREES (EMODIC, OR WALLICH'S REGION).

Altitudes.—5000–12,000 feet. *Mean temperature*, 66°—37° Fahr.

Character.—Tropical forms disappear or decrease: Palmæ, Cycadeæ, Scitamineæ, Euphorbiaceæ, Solanaceæ, Convolvulaceæ, Apocynaceæ, Terebinthaceæ, Leguminosæ, Malvaceæ, Anonaceæ.

Extra-tropical, especially European, forms come to light, or become more abundant than in 7, such as Cariceæ, Amentaceæ, Coniferæ, Polygoneæ (Rumex, Polygonum, Rheum), Primulaceæ (Primula, Lysimachia), Labiatæ, Ericaceæ (Rhododendron, Andromeda), Cichoraceæ, Umbelliferæ, Rosaceæ (Potentilla, Rubus, Rosa, Pyrus, Mespilus, Prunus), Aceraceæ, Caryophyllaceæ (Stellaria, Cerastium, Arenaria), Cruciferæ, Ranunculaceæ (Aconitum, Ranunculus, Thalictrum). The Orchideæ and Ferns are very numerous. Other characteristic forms are the—

Genera.—Allium, Paris, Plantago, Veronica, Rhinanthus, Pedicularis, Didymocarpeæ, Gentiana, Swertia, Campanula, Valeriana, Galium, Cornus, Viburnum.

Most important trees and shrubs.—Pinus Pindrow, P. Webbiana, P. excelsa, P. Khutrow, P. Gerardiana, Abies Smithiana, A. Browniana, Cedrus Deodara, Cupressus torulosa, Podocarpus latifolia, Juniperus squamata, J. excelsa, Quercus spicata, and ten other sp., Corylus ferox, Betula utilis, B. nitida, B. alnoides, Alnus nepalensis, Salix disperma, S. cuspidata, S. japonica, Daphne cannabina, D. Gardneri, D. sericea, D. Bholua, Eleagnus arborea, E. conferta, E. umbellata, Hippophäe salicifolia, Fraxinus floribunda, Ligustrum nepalense, L. bracteolatum, Xylosteum ligutrifum, Caprifolium japonicum, C. macranthum, Cornus oblonga, C. capitata, Viburnum fœtidum, &c., Andromeda formosa, A. ovalifolia, &c., Rhododendron arboreum, R. barbatum, R. Falconeri, and many other sp.; Hedera Hainla, &c., Ilex dipyrena, I. odorata, &c., Ribes takare, Rosa microphylla, &c., Rubus rugosus, R. betulinus, &c., Spiræa canescens, &c., Neillia thyrsiflora, N. rubiflora, Pyrus Pashia, Mespilus affinis, M. Caila, &c., Prunus undulata, P. cerasoides, Rhus juglandifolium, R. fraxinifolium, &c., Rhamnus, sp., Celastrus, sp., Euonymus, sp., Acer acuminatum, A. oblongum, Dobinæa vulgaris, Magnolia, sp., Berberis asiatica, B. Wallichiana, B. miccia.

Note.—The western portion of the Himalayas differs considerably from the eastern portion, from the predominance of Dicotyledonous forests and a damp climate in the former, with a rarity of Conifers until the limit of Abies Smithiana (10,000 feet) is attained, and an extension of the tropical plants to a greater altitude; while in the drier eastern portion the Conifers are diffused throughout, the forests less considerable, and the plants of temperate climates diffused lower down.

Cultivated plants.—The cereals and orchard fruits of Europe, mountain rice, and a few tropical plants in the lower regions.

9.—POLYNESIAN (OR REINWARDT'S) REGION.

Mean temperature, 66°—84° Fahr. *Altitude*, 0—5000 feet.

Character.—Resembling that of the Indian region. The principal distinction consists in the greater number of Orchideæ (especially parasitic species, which appear here in many peculiar forms), of Ferns, and species of Ficus. A slight approximation to the Australian forms: Melaleuca, Metrosideros, Proteaceæ (Heliophyllum). Among the other characteristic forms are the—

Genera.—Licualia, Lodoicea, Rafflesia, Brugmansia, Stemonurus, Antiaris, Myristica, Nomaphila, Hydrophytum, Philagonia, Esenbeckia, Echinocarpus, Aromadendron.

Predominant trees and shrubs.—Primæval forests, composed especially of species of Ficus, Lauraceæ, Calameæ, and Bignoniaceæ, with Licuala speciosa, Lodoicea seychellarum, Broussonetia papyrifera, Artocarpus incisa, Antiaris toxicaria (Upas), Myristica, sp., Ardisia, sp., Tectona grandis, Strychnos Tieute, Diospyros, sp., Barringtonia speciosa, B. excelsa, Philagonia procera, Cereus, sp., Calophyllum Inophyllum, Elæocarpus, sp., Esenbeckia altissima, Echinocarpus Sigun.

Cultivated plants.—The same as in the Indian region, with bread-fruit, cassava, Inocarpus edulis, nutmeg, camphor, papaw, cotton (tree, &c.), paper mulberry, hemp.

10.—UPPER JAVANESE (OR BLUME'S) REGION.

Altitude, 5000–12,000.

Character.—This region bears a certain resemblance to the Emodic region, and ought perhaps to be united with it. Extra-tropical forms replace the tropical. Oak-woods replace the forests of Ficus, and these are succeeded by forests of Podocarpus mingled with Ternstrœmiaceous trees, above which the shrubby heaths (Thibaudia) and woody Gnaphalia occur at a comparatively low elevation (9000) where the trees cease.

Genera.—Plantago, Lysimachia, Veronica, Gentiana, Swertia, Vaccinium, Gaultheria, Vireya, Thibaudia, Bellis, Galium, Saprosma.

Characteristic trees and shrubs—Ternstrœmiaceæ (Cleyera), Gordonia, Schima, (Eurya), Meliaceæ, arborescent Eupatorieæ, Lauraceæ, Ficus, Podocarpus amara, P. imbricata, P. latifolia, P. bracteata, Agathis loranthifolia, Quercus, 16 sp., Myrica javanica, Castanea javanica, C. argentea, &c., Lithocarpus javensis, Engelhardtia spicata, E. rigida, Thibaudia, sp., Bongsoa, sp., Viburnum, sp., Sambucus javanica, Hæmospermum arboreum, Mespilus, sp.

11.—OCEANIC (OR CHAMISSO'S) REGION.

Mean Temperature, 73°—83° Fahr.

Character.—A sparing and not very peculiar flora. Greater approximation to the flora of Asia than to that of Africa; some affinity to the Australian (Casuarina, Proteaceæ, Myoporum, Epacrideæ, Melaleuca, Acaciæ aphyllæ).

Genera.—Schiedea, Antholoma, Aporetica, Crossostylis, Codia, Timonius, Kadua, Cyathostegia, Argophyllum, Melodinus, Ascarina.

Predominant trees and shrubs.—Dracæna terminalis, Tacca pinnatifida, Pandanus odoratissimus, Cocos nucifera, Corypha umbraculifera, Cupressus columnaris, Casuarina equisetifolia, C. nodiflora, Ficus, sp., Artocarpus incisa, Aleurites triloba, Embothrium strobilinum, Scævola Kœnigii, Vaccinium cereum, Lobelia arborea, &c.; Coffea Kaduana, C. Mariniana, Kadua Cookiana, &c., Rhizophora Mangle, R. gymnorhiza, Terminalia Catalpa, Barringtonia speciosa, Melaleuca virgata, &c., Osteomeles anthyllidifolia, Cassia Sophora, Mimosa Mangium, Adenanthera scandens, Blackburnea pinnata, Calophyllum Inophyllum, Clusia sessilis, C. pedicellata, Sapindus Saponaria, Dodonæa spathulata, D. viscosa, Aporetica pinnata, A. ternata, Grewia malacocca, Sterculia Balangas, S. fœtida, Commersonia echinata, Tetracera Euryandra.

Cultivated plants.—Bread-fruit, taro (Arum esculentum), Arum sagittifolium, Arum macrorhizon, Tacca pinnatifida, Convolvulus chrysorhizus, yams (Dioscorea alata), cocoa-nut, banana, Inocarpus edulis, Sterculia Balanghas, Ficus aspera, F. granatum, shaddock, hog-plum (Spondias dulcis), Mimusops dissecta, Terminalia glabra, Cratæva religiosa, Eugenia malaccensis, Dracæna terminalis, Macropiper Methysticum, Areca oleracea, paper mulberry.

12.—REGION OF BALSAMIC TREES (ARABIAN OR FORSKAL'S REGION).

Character.—Tropical; in greatest part Indian forms.

Characteristic genera.—Strœmia, Mærua, Serræa, Oncoba, Caucanthus, Gerumu, Balsamodendron, Cadia, Orygia, Sinbuleta. Some approximation to the South African flora (Stapelia, Hæmanthus).

Predominant trees and shrubs.—Pandanus odoratissimus, Ficus Sycamorus, F. salicifolia, F. populifolia, F. Forskalii, F. palmata, F. serrata, F. Sur, F. Toka, Avicennia tomentosa, Cynanchum arboreum, Balsamodendron gileadense, B. Opobalsamum, B. Kataf, B. Kafal, Celastrus edulis, C. parviflora, Grewia populifolia, Mærua uniflora, M. racemosa.

Cultivated plants.—Millets (species of Sorghum), six-rowed barley, maize, Arum Colocasia, date-palm, plantain, cocoa-nut, tamarind, fig, papaw, peach, apricot, plum, apple, quince, vine, coffee, sugar, ginger, radish, spinach, gourd, Dolichos, sp., tree-cotton, indigo.

Note.—This region extends to the plains of north-east India (Scinde), and should probably include part of Persia, and also of the Abyssinian region.

13.—THE DESERT REGION (DELILE'S REGION).

Mean temperature, 73°—86° Fahr.

Character.—A very poor flora. No characteristic families or genera, but the following species: Pennisetum dichotomum, Phœnix dactylifera, Cucifera thebaica, Euphorbia mauritanica, Aerua tomentosa, Acacia nilotica, A. arabica, A. gummifera, A. Seyal, Cassia obovata, C. Singueana, Alhagi maurorum, Mimosa Habbas, Zizyphus Palma Christi, Zygophyllum simplex, Z. album, Fagonia arabica, F. Oudneyi.

Cultivation.—Only in the Oases; here principally the Date. Doura (Sorghum vulgare), wheat, barley. South-European and certain Indian fruits.

14.—REGION OF TROPICAL AFRICA (ADANSON'S REGION). (THE INTERIOR LITTLE KNOWN).

Mean temperature, 73°—86° Fahr.

Character.—The flora is neither rich in species nor peculiar forms. Leguminosæ, Rubiaceæ, Cyperaceæ very prevalent. Comparatively few species of Palmæ, Filices, Scitamineæ, Piperaceæ, Passifloreæ.

Genera.—Adansonia, Melhania, Christiania, Pentadesma, Napoleona, Parkia, Heudusia, Thonningia.

Predominant trees and shrubs.—Anona senegalensis, &c., Cadaba farinosa, Cratæva Adansonii, Capparis edulis, Pentadesma butyracea, Bombax pentandrum, B. guineense, Adansonia digitata, Sterculia acuminata, Grewia carpinifolia, Acacia, sp., Cassia occidentalis, Pterocarpus esculentus, Parkia africana, Chrysobalanus Icaco, Conocarpus pubescens, Rhizophora, sp., Psychotria, sp., Bignonia tulipifera, Avicennia africana, Euphorbia (shrubby species), Ficus, sp., Elais guineensis, E. melanococca, Rhapia vinifera, Phœnix spinosa, Pandanus candelabrum.

Cultivated plants.—Maize, rice, millets (Sorghum vulgare, saccharatum, Panicum, sp.), yams (Diosc. alata, sativa), cassava, Arum esculentum, plantains, mango, papaw, pine-apple, oil-palm, cashew-nut, figs, tamarind, Citrus, sp. (oranges, limes, lemons, &c.), coffee, sugar, ginger, cardamoms, grains of Paradise, &c., beans of various kinds, and Dolichos pulses, ground-nut (Arachis), edible Solana, cotton, tobacco.

15.—REGION OF CACTI AND PIPERACEÆ (JACQUIN'S REGION).

Altitude, 5000 feet. *Mean temperature*, 68°—84° Fahr.

Character.—

Families.—Bromeliaceæ, Piperaceæ, Passifloreæ, Cactaceæ, numerous tropical families, Euphorbiaceæ, Convolvulaceæ, Apocynaceæ, Rubiaceæ. Tropical families less frequent here than in other places within the tropics; Filices, Scitamineæ, Orchidaceæ, Myrtaceæ, Leguminosæ, Terebinthaceæ, Aurantiaceæ, Tiliaceæ, Malvaceæ. Extra-tropical families appearing or becoming more abundant; Labiatæ, Ericaceæ, Campanulaceæ, Compositæ, Umbelliferæ, Crassulaceæ, Rosaceæ, Caryophyllaceæ, Cruciferæ, Ranunculaceæ.

Characteristic genera.—Phytelephas, Kunthia, Galactodendron, Podopterus, Salpianthus, Russellia, Lagascea, Gronovia, Inga, Thouinia, Lacepedia, Theobroma, Guazuma.

Predominant trees and shrubs.—Cyathea spinosa, C. villosa, Meniscium arborescens, Agave americana, Yucca acaulis, Cocos nucifera, C. butyracea, Mauritia flexuosa, Martinezia caryotifolia, Oreodoxa montana, Kunthia montana, Chamærops Merini, Corypha Miraguama, C. Pumos, C. tectorum, &c., Liquidamber styraciflua, Cecropia peltata, Galactodendron utile, Rhopala ovata, Avicennia tomentosa, Ehretia ternifolia, Cordia dentata, Cereus, sp., Melocactus, sp., Opuntia, sp., Pereskia, sp., Mammillaria, sp., Lecythis elliptica, &c., Bertholletia excelsa, arborescent Melastomæ, Bauhinia splendens, B. suaveolens, &c., Hæmatoxylon campechianum, Cæsalpinia cassioides, &c., Acacia cornigera, A. fœtida, &c., Hymenæa Courbaril, &c., Inga Humboldtiana, I. insignis, &c., Mimosa, sp., Swietenia Mahogani, Bouplandia trifoliata.

Cultivated plants.—Maize, doura, cassava, yam, batatas, plantain, mango, custard-apples, guavas, cocoa-nut, papaw, peach, pine-apple, cashew-nut, tamarind, species of Citrus, granadilla, vine, cactus-fig, rose-apple, cocos, vanilla, coffee, sugar, tomatoes, capsicums, pigeon-pease (Cajanus), ground-nut, cochineal cactus, tobacco, cotton.

16.—REGION OF THE MEXICAN HIGHLANDS (BONPLAND'S REGION).

Altitude, above 5000 feet. *Mean temperature*, 67°—79° Fahr.

Character.—Tropical forms vanishing or decreasing; Tree-ferns, Palmæ, Piperaceæ, Euphorbiaceæ, Melastomaceæ, Passifloreæ. Extra-tropical forms make their appearance or become more abundant; Amentaceæ (Salix, Quercus), Coniferæ (Pinus, Cupressus), Labiatæ (Salvia, Stachys, Marrubium), Pedicularis, Anchusa, Myosotis, Polemonium, Ericaceæ (Vaccinium, Arbutus, Arctostaphylos), Compositæ (very much increasing), Valeriana, Galium, Cornus, Caprifolium, Umbelliferæ, Rosaceæ (Amygdalus, Mespilus, Rosa, Potentilla), Caryophylleæ (Arenaria), Cruciferæ (Draba), Ranunculaceæ (Anemone, Ranunculus).

Characteristic genera.—Mirabilis, Maurandya, Leucophyllum, Holtzia, Georgina, Zinnia, Schkuhria, Ximenesia, Lopezia, Vauquelinia, Choisya, Cheirostemon.

Predominant trees and shrubs.—Pinus occidentalis, Abies hirtella, Cupressus thurifera, C. sabinoides, Taxodium distychum, Quercus (16 sp.), Salix Bonplandiana, S. paradoxa, &c., Arbutus mollis, A. petiolaris, Arctostaphylos polifolia, A. pungens, &c., Vaccinium geminiflorum, V. stamineum, V. confertum, Rosa Montezumæ, Mespilus pubescens, Amygdalus microphylla, Cheirostemon platanoides.

Cultivated plants.—Maize, European cereals and fruits.

Note.—In the uppermost regions of the mountains the flora acquires an alpine aspect. Here occur Cyperus Toluccensis, Chelone gentianoides, Cnicus nivalis, Ageratum arbutifolium, Senecio (many procumbent species), Potentilla ranunculoides, Lupinus elegans, L. montana, Arenaria bryoides.

17.—REGION OF CINCHONAS (HUMBOLDT'S REGION).

Altitude, 5000—9000 feet. *Mean temperature*, 59°—68° Fahr.

Character.—Extra-tropical forms make their appearance, or become more frequent. Graminaceæ, Amentaceæ, (Quercus, Salix), Labiatæ (Salvia, Stachys, Scutellaria), Anchusa, Myosotis, Swertia, Ericeæ, Compositæ (very numerous), Caprifoliaceæ (Viburnum, Sambucus), Umbelliferæ (Ferula, Ligusticum), Rosaceæ, Cruciferæ, Ranunculaceæ. On the other hand, certain tropical forms vanish or become rarer, but a few particular species of Palmæ, Piperaceæ, Cactaceæ, Passiflora, and Melastomaceæ, ascend to a considerable altitude.

Genera.—Lilæa, Cervantesia, Oreocallis, Lachnostoma, Gaylussaccia, Stevia, Flaveria, Tagetes, Espeletia, Cinchona, Guilleminia, Loasa, Kageneckia, Negretia, Amicia, Perottetia, Dalongea, Laplacea, Fraziera, Abatia, Monnina.

Predominant trees and shrubs.—Oreodoxa frigida, Ceroxylon andicola, Podocarpus taxifolia, Salix Humboldtiana, Quercus Humboldtiana, Q. almaguerensis, Q. tolimensis, Ficus velutina, Rhopala cordifolia, Oreocallis grandiflora, Persea lævigata, P. Mutisii, P. sericea, Ocotea mollis, O. sericea, Vaccinium caracasanum, Andromeda bracamorensis, Befaria glauca, B. ledifolia, Cinchona Condaminea, C. cordifolia, C. oblongifolia, C. lancifolia, &c., Weinmannia elliptica, W. Balbisiana, &c., Osteomeles glabrata, Rubus floribundus, Ilex bumelioides, I. myricoides, Clusia elliptica.

Cultivated plants.—The tropical cultivated plants mentioned under 15 almost entirely disappear; maize and coffee, however, are cultivated in this region; after these come the European cereals and fruits, potatoes, and Chenopodium Quinoa.

18.—REGION OF ESCALLONIÆ AND CALCEOLARIÆ (RUIZ AND PAVON'S REGION).

Altitude, 9000—18,000 feet. *Mean temperature*, 59°—34° Fahr.

Character.—The tropical forms have disappeared almost entirely, but the following genera still occur: Tillandsia, Oncidium, Peperomia, Rhexia, Passiflora. The forms which characterise the colder temperate and the polar zones become more common: Lichenales, Musci, Carex, Luzula, Alnus, Rumex, Plantago, Gentiana, Swertia, Vaccinium, Campanula, Cacalia, Senecio, Umbelliferæ, Valeriana, Saxifraga, Ribes, Rubus, Alchemilla, Caryophyllaceæ (Sagina, Arenaria, Cerastium, Stellaria), Cruciferæ (Draba, Arabis).

Predominant families.—Compositæ, Graminaceæ, Ericaceæ. No large trees.

Characteristic genera.—Desyeuxia, Tigridia, Gardoquia, Calceolaria, Thibaudia, Lysipoma, Barnadesia, Homanthis, Chuquiraga, Culcitium, Wernera, Dumerillia, Escallonia, Pectophytum, Klaprothia, Polylepis.

Predominant shrubs.—Alnus ferruginea, A. acuminata, Vaccinium acuminatum, V. empetrifolium, V. floribundum, &c., Thibaudia rupestris, T. floribunda, T. longifolia, T. strobilifera, Befaria grandiflora, B. coarctata, Ribes frigidum, Escallonia myrtilloides, E. tortuosa, E. Tubar, E. berberidifolia, Ilex scopulorum, Drimys granatensis.

19.—WEST INDIAN (OR SWARTZ'S REGION).

Mean temperature, 59°—79° Fahr.

Character.—The flora of this group of islands approaches that of the Continent, but is distinguished especially (like the Polynesian from the Indian flora), by the great quantity of Filices and Orchidaceæ. In addition to these families, we find among the characteristic forms the following

Genera.—Thrinax, Epistylium, Alchornea, Tanæcium, Tetranthus, Catesbæa, Belonia, Portlandia, Picramnia, Legnotis, Lithophila, Valentinia, Hypelate.

The following are deserving of mention among the predominant trees and shrubs: Cocos nucifera, Pinus occidentalis, Laurus, sp., Melastoma, sp., Myrtus, sp., Sterculia, sp., Uvaria, sp.

Cultivated plants the same as in 15.

20.—REGION OF PALMS AND MELASTOMÆ (MARTIUS'S REGION).

Mean temperature, 59°—84° Fahr.

Character.—Probably that portion of the globe in which the vegetable kingdom presents the greatest profusion and variety. Abundance of genera and species, magnitude of individuals, impenetrable (primæval) forests, numerous climbing and parasitical plants. Among the characteristic although not peculiar families, may be named, Palmæ, Ennodoraceæ, Gesneraceæ, Melastomaceæ, and Sapindaceæ; the Vochysiaceæ are peculiar. The peculiar genera are too numerous to be all mentioned here; among those richest in species are the:—

Genera.—Vellosia, Barbacenia, Manihot, Franciscea, Ditassa, Lycnophora, Diplusodon, Kielmeyera, Sauvagesia, Lauradia.

Characteristic genera and species, according to the different modes of occurrence.—In the Primæval forests, Palms of various genera, Thoa, Ficus, Cecropia, Anda, Rhopala, Myristica, Bignonia, Theophrasta, Stiftia, Oxyanthus, Coutarea, Psychotria, Bertiera, Feuillea, Carica, Myrtus, Gustavia, Lecythis, Bertholletia, Melastoma, Hymenæa, Dimorpha, Trattinickia, Pilocarpus, Trichilia, Cedrela, Cupania, Banisteria, Hippocratea, Caryocar, Marcgravia, Clusia, Calophyllum, Sloanea, Göthea, Lebretonia, Abroma, Carolinea, Bixa, Uvaria.

In the Catingas (or open woods, where the trees lose their leaves in the dry season), Jatropha, sp., Acacia, sp., Mimosa, sp., Cæsalpinia pubescens, &c., Spondias tuberosa, Thryallis brasiliensis, Chorisia ventricosa, Bombax, sp., Eriodendron, sp., Pourretia ventricosa, Capparis lineata, &c., Anona obtusifolia, &c.

In the Campos, (open treeless plains): Paniceæ, Amaryllis, Alstrœmeria, Vellosia, Barbacenia, Burmannia, Stelis, Cnemidostachys, Rhopala, Laurus, Ocotea, Gomphrena, Lantana, Echites, Hancornia speciosa, Gesnera, Lycnophora, Baccharis, Vernonia, Mikania, Stevia, Melastoma, Rhexia, Terminalia fagifolia, Gaudichaudia, Sauvagesia, Lauradia, Plectanthera.

On the sea-coasts: Cocos schizophylla, Diplothemium maritimum, Eriocaulon, sp., Xyris, sp., Avicennia tomentosa, Rhizophora Mangle, Conocarpus erectus, Laguncularia racemosa, Bucida Buceras.

Cultivated plants, about as in 15.

21.—REGION OF THE WOODY COMPOSITÆ (OR ST HILAIRE'S REGION).

Mean temperature, 59°—74° Fahr.

Character.—The tropical forms decrease or vanish; extra-tropical, especially European, forms take their place: Ranunculaceæ, Cruciferæ, Helianthemum, Caryophyllaceæ, Lathyrus, Galium, Teucrium, Plantago, Carex; a few South African forms, Polygala, Oxalis, Gnaphalium. This region has more than half its genera in common with Europe. Numerous Compositæ; many among these woody.

Genera.—Larrea, Hortia, Diposis, Boopis, Acicarpha, Cortesia, Petunia, Jaborosa, Tricycla, Caperonia, Bipennula. In great part consisting of open flat plains (Pampas), over which grasses and thistles prevail.

Cultivated plants.—Mostly the European: wheat, vine. The peach is very widely spread.

22.—THE ANTARCTIC REGION (D'URVILLE'S REGION).

Mean temperature, 41°—48° Fahr.

Character.—Great resemblance to the North European flora (Region 2). The tropical forms have entirely vanished.

Predominant families.—Compositæ, Graminaceæ, Cariceæ, Musci, Lichenes. The following are also common: Ranunculaceæ, Cruciferæ, Caryophyllaceæ, Rosaceæ, Umbelliferæ. Two-thirds of the genera in common with Europe. A slight approximation to South Africa (Gladiolus, Witsena, Galaxia, Crassula), and to Australia (Embothrium, Ourisia, Stylideæ, Muiarum).

Characteristic genera.—Gaimardia, Astelia, Callixine, Philesia, Drapetes, Fæa, Calceolaria, Pernettia, Oligosporus, Nassavia, Bolax, Azorella, Donatia, Acæna, Hamadryas.

Predominant trees and shrubs.—Fagus antarctica, Salix magellanica, Embothrium coccineum, Pernettia empetrifolia, P. mucronata, Andromeda myrsinites, Baccharis tridentata, Chiliotrichum amelloides, Ribes magellanicum, Escallonia serrata, Fuchsia coccinea, Myrtus nummularia, Berberis ilicifolia, B. inermis, B. microphylla, B. empetrifolia, Drimys Winteri. No cultivation.

23.—REGION OF STAPELIÆ AND MESEMBRYANTHEMA (THUNBERG'S REGION).

Mean temperature, 54°—73° Fahr.

Character.—A flora very rich in forms, but not luxuriant; no large dense forests, or abundance of climbing plants, &c.; many succulent plants.

Characteristic families.—Restiaceæ, Iridaceæ, Proteaceæ, Ericaceæ, Ficoideæ, Bruniaceæ, Diosmeæ, Geraniaceæ, Oxalideæ, Polygalaceæ.

Genera.—Restia, Ixia, Gladiolus, Moræa, Watsonia, Hæmanthus, Strumaria, Agapanthus, Eucomis, Massonia, Strelitzia, Aphyteia, Passerina, Gnidia, Protea, Leucadendron, Leucospermum, Serruraria (and many other Proteaceæ). Stilbe, Selago, Stapelia, Erica, Gnaphalium, Elichrysum, Stobæa, Pteronia, Osteospermum, Tarchonanthus, Relhania, Gorteria, Arctotis, Othonna, Stæbe, Œdera, Anthospermum, Mesembryanthemum, Vahlia, Liparia, Borbonia, Lebeckia, Raffnia, Aspalathus, Stavia, Brunia, Phylica, Diosma, Pelargonium, Oxalis, Sparmannia, Muraltia, Polygala, Penæa.

Predominant forms.—On the sandy districts of the coasts: Stapelia, Iridaceæ, Mesembryanthemum, Restia, Diosma. On the mountains: Proteaceæ, Erica, Crassula, &c. On the dry plateaux: Acacia capensis, A. giraffæ, A. detinens, A. viridamis, Euphorbia mauritanica, E. tenax, Poa spinosa, Mesembryanthemum, sp., Aloe, Iridaceæ, Erica, Diosmeæ, Restia.

Other remarkable species.—Hæmanthus coccineus, Amaryllis toxicaria, Testudinaria montana, T. elephantipes, Podocarpus elongatus, Salix gariepina, Protea mellifera, P. grandiflora, Leucadendron argenteum, Laurus bullata, Lycium tetrandrum, Olea similis, Rhizogum trichotomum, Tarchonanthus camphoratus, Stæbe rhinocerotis, Crassula coccinea, Portulacaria afra, Mesembryanthemum edule, M. turbiniforme, Metrosideros angustifolia, Acacia elephantina, Zizyphus bubalina, Calodendron capense.

Cultivated plants.—The European cereals, fruits, and esculent vegetables; also Sorghum caffrorum, batatas, plantains, tamarind, guava, shaddock.

24.—REGION OF THE EUCALYPTI AND EPACRIDES (ROBERT BROWN'S REGION).

Mean temperature, 53°—73° Fahr.

Character.—One of the richest and most peculiar floras, but without any considerable profusion of vegetation.

The characteristic families and genera are—Xerotes, Xanthorrhæa, Pterostyles, Casuarinæ, Leptomeria, Pimelea, Proteaceæ (Banksia, Hakea, Persoonia, Grevillea, Petrophila, Isopogon, Dryandra), Myoporineæ, Westringia, Logania, Metrosarme, Epacridaceæ (Epacris, Leucopogon, Styphelia), Stackhouseæ, Scævoleæ, Goodenovieæ, Stylideæ, Eucalyptus, Melaleuca, Leptospermum, Acaciæ aphyllæ, Platylobium, Bossiæa, Diosmeæ (Boronia, Zieria), Pittosporeæ, Tremandreæ, Pleurandra, Hibbertia.

Predominant trees and shrubs.—Three-fourths of the forests are composed of species of Eucalyptus, the number of which amounts to more than a hundred. Next to these come Proteaceæ, Epacrideæ, Diosmeæ, Casuarinæ, and Acaciæ aphyllæ, forming woods and "bush." Also Coniferæ, Araucaria excelsa, A. Bidwilli, A. Cunninghamii, Cookii, Dacrydium Franklinii, Podocarpus spinulosa.

Cultivated plants.—In the European colonies, the cereals, fruits, and vegetables of Europe.

25.—NEW ZEALAND REGION (FORSTER'S REGION).

Temperate climate.

Character.—Tropical forms vanish, or appear but sparingly. Half the genera European. Approximation to Australia (Pimelia, Myoporum, Epacris, Styphelia, Cassinia, Melaleuca); to South Africa (Restia, Gnaphalium, Xeranthemum, Tetragonia, Mesembryanthemum, Oxalis); to the Antarctic region (Muiarum, Fuchsia, Acæna, Dryadis). Very many Ferns.

Genera.—Phormium, Pennantia, Knightia, Forstera, Shavia, Griselinia, Melicope, Dicera, Plagianthus, Melicitus.

Characteristic species.—Cyathea medullaris, Gleichenia furcata, Dracæna indivisa, D. australis, Phormium tenax, Areca sapida, Dacrydium taxifolium, Dammara australis, Podocarpus totarra, Knightia excelsa, Avicennia resinifera, Andromeda rupestris, Epacris juniperina, &c., Weinmannia racemosa, Tetragonia expansa, Fuchsia excorticata, Melaleuca, sp., Dicera dentata, D. serrata.

Cultivated plants.—Arum esculentum, Convolvulus chrysorhizus, Phormium tenax (New Zealand hemp), paper mulberry. In the European colonies the cereals, fruits, and esculents of Central Europe.

V. SUMMARY OF THE PLANTS HAVING A SPECIAL INFLUENCE ON THE PHYSIOGNOMY OF THE VEGETATION OF REGIONS.

The classification of plants, under this point of view, proceeds on a distinct principle, and differs widely from a natural classification based on structural and physiological affinities. What we have to do with here is resemblance or diversity of those parts which make up the great bulk or mass of vegetable objects—those parts which strike the eye first, when they are looked at as a whole or as part of a landscape. The foliage, with the trunk and its ramifications supporting the leaves, commonly acquire here more importance than the ordinarily comparatively small and delicate structures of the flower. The organs of nutrition thus obtain a superiority over those of reproduction, the converse of what holds good in the majority of cases in a physiological classification, wherein the structures connected with the seeds and spores, as the highest products of vegetable organisation, have the greatest value attached to them.

The physiognomical method is recognisable in the crude attempts at arrangement made in the earlier days of science, and, moreover, in the classifications which find their expression in common language—such as the division of plants into herbs, shrubs, and trees, &c.; and in like manner colonists always unconsciously carry out some such mode of classification in applying names to the various new plants, and especially trees, they meet with, according to real or fancied resemblance to those of their native land.

The independence of the general aspect of plants, as given by the trunk and foliage, of the physiological and structural peculiarities of the organs of reproduction, is often remarkable. Thus, while the Palms, the Conifers, the Umbelliferæ, Grasses, Ferns, &c., afford examples of striking agreement within the limits of families, the Leguminosæ, Rosaceæ, Liliaceæ, and others, exhibit as evident a diversity. Great resemblance is often seen also between members of families widely separated in their natural affinities—as between the Palms and the Cycads, Equisetum and Ephedra, the Cactaceæ and some of the Euphorbiaceæ, &c.

In the following groups, then, very distinct plants are occasionally brought together, solely on account of their external resemblance causing them to produce a similar effect upon the character of the landscape.

In the Map, the names of the groups are printed in red letters, the subdivisions of the forms of forest trees in large black letters, and the genera and families included in the other groups in small black letters.

I. BROAD-LEAVED FOREST TREES.—1. *Trees with large and beautifully-formed leaves.*—Malvales (*Hibiscus, Lavatera, Sterculia, Adansonia*); Artocarpeæ (*Cecropia, Artocarpus*—bread-fruit), *Ficus* (figs), *Broussonetia* (paper mulberry); Euphorbiaceæ (*Jatropha, Siphonia, &c.*—Caoutchouc trees—*Croton, Ricinus*); Urticeæ (*Stilago*). Characteristic of the equatorial and tropical zones. 2. *Trees with thick, leathery, and shining leaves.*—Chestnut, laurel, and olive woods; *Camelliæ*; oranges, magnolias. Characteristic of the sub-tropical and warm temperate zones. Succeeding the foregoing on the mountains of the tropical zones. 3. *Trees with broad and delicate leaves.*—Beeches, horse-chestnuts, oaks, limes, elms, birches, alders, and poplars. Characteristic of the cold temperate zones. Succeeding the preceding on the mountains near the equator. 4. *Willows.*—*Salix alba, viminalis, Caprea, cinerea, &c.* Characteristic of the temperate and sub-arctic zones.

II. MYRTLE-LIKE PLANTS.—*Myrtus* (America and Southern Europe), *Melaleuca, Metrosideros, Leptospermum, Eucalyptus* (New Holland), *Psidium, Eugenia* (West Indies and South America), *Barringtonia, Jambosa, Eugenia* (East Indies).

III. CONIFEROUS OR NEEDLE-LEAVED TREES.—1. *Pinus, Abies* (pines and firs), larches, yews. Characteristic of the cold temperate and sub-arctic zones of the northern hemisphere, and of elevated regions in the sub-tropical and warm temperate zones. 2. *Araucaria* (South America and New Holland), *Cupressus* (New Holland), with which may be associated the *Casuarinæ* or beef-woods (Malay peninsula, New Holland, and South Sea Islands). Characteristic in the southern hemisphere.

IV. HEATH-LIKE SHRUBS.—1. *Erica* (true heaths), *Passerina, Phylica, Diosma, Gnidia.*—Characteristic of the Cape of Good Hope and of Southern Europe. 2. *Proteæ.*—*Protea, Banksia, Dryandra, &c.*—Characteristic of the Cape of Good Hope and New Holland. 3. *Epacrideæ*—*Epacris, Lissanthe, Leucopogon.*—Characteristic of New Holland.

V. MIMOSA-LIKE PLANTS.—1. *Mimosa* (South America), *Sophora* (East Indies), *Inga* (East Indies and South America), *Acacia* (India and Africa.)—Characteristic of the tropics. 2. *Acacia* (South America, New Holland, South Sea Islands), *Prosopis* (South America), *Gleditschia* and *Robinia* (North America and Central Asia).—Characteristic of the sub-tropical and warm temperate zones.

VI. FERNS.—1. *Tree Ferns.*—Characteristic of the equatorial and tropical zones, and East Indian Islands. 2. *Shrubby Ferns.*—Characteristic of the tropical and sub-tropical zones, and South Sea Islands. 3. *Herbaceous Ferns.*—Characteristic of the temperate and cold zones, and also, as epiphytes, of the warmer zones.

VII. PALMS.—1. *Tall Palms.*—*Borassus flabelliformis* (fan-palm), *Phœnix umbraculifera* (umbrella-palm), *Cocos nucifera* (cocoa-nut), *Phœnix dactylifera* (date-palm), *Areca Catechu* (areca-palm), *Areca oleracea* (cabbage palm), &c.—Characteristic of the equatorial and tropical zones. 2. *Palms without elevated trunks.*—*Chamærops humilis* (dwarf-palm), (Southern Europe). *Chamærops Palmetto* (palmetto), (Florida), *Nipa fruticans* (Philippines and Moluccas). 3. *Cane Palms.*—*Calamus* (East Indies). To which may be subjoined the palm-like: 4. *Cycads.*—*Cycas* (South Asia), *Zamia, Encephalartos* (South Africa and New Holland).

VIII. ALOE-LIKE PLANTS.—*Agave* (American aloe), *Yucca, Fourcroya* (tropical America), *Aloe, Stapelia* (sub-tropical Africa).

IX. BROMELIACEÆ (PINE-APPLE TRIBE).—*Bromelia, Tillandsia, Pitcairnia.* Equatorial to the sub-tropical zone of America, frequently as epiphytes.

X. PANDANUS-LIKE PLANTS.—*Pandanus* (screw pine), *Freycinetia, Dracæna* (dragon-tree), *Phormium tenax* (New Zealand flax). Tropical zones and South Sea Islands.

XI. SCITAMINEÆ.—1. *Bananas, Plantains, &c.*—*Musa, Heliconia, Strelitzia.* 2. *Arrow-root plants.*—*Maranta* (arrow-root plants), *Canna* (tous-les-mois). Equatorial to sub-tropical zones.

XII. GRASS-LIKE PLANTS.—1. *True Grasses* (*Graminaceæ*)—*a. Arborescent grasses.*—*Bambusa, Sacchárineæ, Oryzeæ Paniceæ.* Equatorial to the sub-tropical zones. *b. Grasses forming meadows and pastures.*—*Hordeaceæ, Bromeæ, Agrostideæ.* Cold-temperate to the sub-arctic zones. 2. *Sedgy plants and rushes.*—*Cyperoideæ* and *Juncaceæ.* *a. Cyperus, Eriocaulon, Restia.* Equatorial to the sub-tropical zone. *b. Carex.*—*Eriophorum, Scirpus, Juncus.* The colder zones.

XIII. CACTUS-LIKE PLANTS.—1. *Columnar Cacti.*—*Cactus, Cereus.* 2. *Leaf-like Cacti.*—*Opuntia, Rhipsalis, Pereskia.* America, between 40° N. L. and 40° S. L. 3. *Globular Cacti.*—*Melocactus, Echinocactus, Mammillaria.* The torrid zone of America. 4. *Cactus-like Euphorbiæ.*—*Euphorbia meloformis, E. mammillaris, E. trigona, E. neriifolia, &c.* Torrid zone of the Old World.

XIV. SUCCULENT OR FLESHY PLANTS.—1. *Crassulaceæ.*—*Crassula, Cotyledon* (South Africa), *Sedum, Sempervivum* (North America and Southern Europe). 2. *Ficoideæ.*—*Mesembryanthemum* (South Africa), *Sesuvium* (East Indies), *Aizoon* (North Africa).

XV. LILY-LIKE PLANTS.—1. *Liliaceæ.*—*Lilium, Tulipa* (Asia), *Fritillaria, Hemerocallis* (Southern Europe). 2. *Amaryllideæ.*—*Amaryllis* (South Africa), *Alstrœmeria* (South America), *Narcissus* (Southern Europe and North Africa). 3. *Irideæ.*—*Iris, Tigridia, Ixia* (South Africa, Mexico), *Gladiolus* (Southern Europe and Cape of Good Hope).

XVI. LIANES, OR CLIMBING PLANTS.—1. In the torrid zone—*a. Passiflora, Bignonia, Banisteria, Paullinia, Aristolochia, Bauhinia, Ipomœa,* in the New World. *b. Calamus, Vitex, Cissus, Aralia, Asclepias,* in the Old World. 2. In the warm temperate zone, the vine. 3. In the cold temperate zone, the hop, honeysuckle, black and white bryony.

XVII. POTHOS-LIKE PLANTS.—*Pothos, Dracontium, Caladium* (Tropical America), *Calla æthiopica* (Africa), *Arum* (Southern Europe, East Indies, America); almost all Epiphytes.

XVIII. ORCHIDEÆ.—*Cymbidium, Dendrobium, Aërides, Vanda, Epidendrum, Vanilla.* Epiphytic in the torrid zone of the Old and New Worlds.

XIX. MOSS-LIKE PLANTS.—*Sphagnum* (bog-moss), *Dicranum.* In northern regions, growing on trees, banks, rocks, &c. *Jungermannia* and *Selaginella,* as epiphytes or false parasites in tropical regions.

XX. LICHENS OR SCALE-MOSSES.—*Usnea, Ramalina, Cenomyce rangiferina* (reindeer moss), *Cetraria islandica* (Iceland moss), and *Gyrophora* in North America. Growing over the bark of trees, rocks, and barren ground.

VI. STATISTICS OF PLANTS.

Theophrastus (390 B.C.) enumerated 500 kinds of plants, and Pliny (A.D. 79), in his *Historia Naturalis*, increased the number to double. The researches of the Greek, Roman, and Arab naturalists made known no more than 1400 species, and even in the beginning of the seventeenth century the discrimination of the different kinds had only raised the number of distinguished forms to 6000, as we find from Lobel and J. Bauhin. The second edition of Linnæus's *Species Plantarum* (1762) contained no more than 8800 species, Murray's edition of the *Systema Naturæ* only 10,042 species, including the Cryptogamia.

Willdenow's edition of the *Species Plantarum*, the publication of which extended from 1797 to 1807, described 17,457 species of flowering plants, and, adding the Cryptogamia, we obtain the number, 20,000, mentioned by him. Since that time the number of known species and the estimates of the probable number existing have increased very rapidly. R. Brown (*General Remarks on the Botany of Terra Australis*) counted above 37,000 Phanerogamia; and Humboldt (*De Distributione Geographica Plantarum*) spoke of 44,000 plants, Phanerogamous and Cryptogamous, at the beginning of the present century.

Decandolle (*Essai Elementaire de Geographie Botanique*, 1820,) next calculated that the writings of botanists, and the various European collections of dried specimens, might be assumed to contain, together, upwards of 56,000 species of plants. In 1820, however, the number of species in the herbarium of the Jardin des Plantes was estimated at the same number, and the collection of M. Benjamin Delessert of Paris was supposed to contain at the time of his death, in 1847, as many as 86,000 species, a number which, about twelve years previously, had been conjectured by Lindley to represent the whole of the species existing on the globe (*Introduction to Botany*, second edition, 1835). The Royal Herbarium at Schonberg, near Berlin, is estimated by Dr Klotsch to contain 74,000 distinct species.

Humboldt (*Aspects of Nature*) has entered into some interesting calculations to prove how far all these figures fall short of the number of species of plants which may be supposed to exist. The number of species of flowering plants named in Loudon's *Hortus Britannicus* (1832), as at that time, or within a moderate period before, cultivated in Britain, was 26,660; the catalogue of species actually under cultivation in the Berlin Garden, carefully prepared by Kunth, gave rather more than 14,060 species, 375 of which were ferns, leaving 13,685 flowering plants. Among these the following important families were represented: the Compositæ by 1600 species, the Leguminosæ by 1150, the Labiatæ by 428, the Umbelliferæ by 370, the Orchideæ by 400, the Palms by 60, and the Grasses and Cyperaceæ by 600 species.

When these numbers are compared with those of the species of their families described in recent works, we find that this garden contains only 1-7th of the Compositæ (about 10,000, Decandolle and Walpers); 1-8th of the Leguminosæ (8068); and 1-9th of the Grasses (Grasses 3544, Cyperaceæ 2000, Kunth); and of the smaller families of Labiatæ (2190), and Umbellifera (1620), about 1-5th or 1-4th.

Supposing all the flowering plants cultivated at one time in all the botanic gardens of Europe to amount to 20,000, and assuming from the foregoing comparisons that the cultivated species amount to about the eighth of those described and preserved in collections, the latter would amount to 160,000 species. Large as this number is, it will scarcely be thought excessive, when we recollect how small a proportion of many large families is to be found in our gardens—scarcely 1-100th part, for example, of the Guttiferæ, Malpighiaceæ, Melastomeæ, Myrtaceæ, and Rubiaceæ.

If we apply this mode of calculation to the number of species given by Loudon (26,660), the estimate of 160,000 rises to 213,280 species; and this is still moderate, since Heynhold's *Nomenclator botanicus hortensis* of 1846 rates the cultivated flowering species at 35,600.

These deductions, based on Kunth's inferences, refer to the proportion of the species cultivated in gardens, to the entire number hitherto described and now existing in herbaria. The next point is to consider the proportion borne by the latter to the probable sum of the species actually living upon the globe at the present time, and to test the assumed minimum of this by the relative number of species in the different families. Such a test, however, gives, even for the minimum, results so low that we find, even in the large families, to which so many new species have recently been added, that we are still acquainted only with a small portion of the existing plants.

Walpers's *Repertorium*, supplementary to Decandolle's *Prodromus*, brings the number of Leguminosæ up to 8068 species in 1846. The proportion of the number of the Leguminosæ to that of the entire Phanerogamous flora is 1-10th within the tropics, 1-18th in the temperate, and 1-35th in the north frigid zone; so that we may assume the mean proportion of this family to be 1-21st. The 8068 described Leguminosæ would therefore lead us to suppose that there existed only 169,400 species of flowering plants upon the surface of the globe, whereas the Compositæ, as stated above, indicate, by Kunth's mode of deduction, more than 160,000 already *known* species.

Of the Compositæ, Linnæus was acquainted with only 785 species, while 10,000 are now known. The greater part of these appear to belong to the Old World, Decandolle describing only 3590 American, with 5093 for Europe, Asia, and Africa. But this seeming abundance of the Compositæ is to a certain extent deceptive and only apparent. The proportions of this family are—1-15th between the tropics, 1-7th in the temperate, and 1-13th in the frigid zones, giving a mean of 1-12th, which shows that even more species of Compositæ than of Leguminosæ have escaped investigation hitherto, since a multiplication by twelve would give us the improbably low number of 120,000 Phanerogamia.

The Grasses and Cyperaceæ give still lower results, as comparatively fewer still of these have been collected and described. The mean proportion of the Grasses seems to be about 1-12th. Taking the number of known species of plants according to the above calculations at 160,000 or 213,280, the Grasses ought to amount to 13,333 in the first case, and 17,773 in the second, while only either 1-4th or 1-5th of these numbers are known. When we reflect what enormous extent of plain still remains unexplored in almost all parts of South America, and in Northern and Central Asia, this deficiency does not appear extraordinary; and indeed it becomes by no means difficult to believe that we are so deficient of knowledge of species of Grasses that the total number of flowering plants might be taken at double the number known, which would lead to the conclusion that only 1-8th or 1-10th of the Grasses had as yet been discriminated.

The assumption that the number of existing Phanerogamic species amounts to more than double those we know, is borne out by many circumstances. We are still unacquainted with large portions of the interior of South America, Mato-Grosso, Paraguay, the eastern slope of the Andes, Santa Cruz de la Sierra, and all the countries between the Orinoco, the Rio Negro, the Amazon, and the Purus—of Africa, Madagascar, Borneo, New Guinea, Australia, and Central and Eastern Asia. Drège collected upwards of 7000 species in South Africa alone, and he calculated that the flora of the district contained 11,000 species: while an equal area in Germany or Switzerland contains 3300 (Koch), and in France 3645 (Decandolle) species. Humboldt added several thousand species of flowering plants, and among them tall trees, in his South American expedition, in countries previously examined to a considerable extent by other botanists. The probability is, that as the floras of the more southern climates are rather rich in individuals, and poor in diverse species, the great bulk of undiscovered flowering plants have to be sought in the tropical countries, and from 10° to 15° beyond the tropics.

The fact is well known that the number of species increases towards the equator, as a general rule, only liable to exception when the peculiar conformation of the country deprives it of the supply of moisture absolutely requisite under such a temperature. The great number of species of the tropics corresponds to a greater number of genera and families, and these therefore also diminish in number towards the poles. But each genus or family is likewise commonly represented by a smaller number of species in cold regions, and thus the proportion of the genera to the number of species becomes higher. Thus the French flora contains above 7000 species, belonging to somewhat more than 1100 genera, the Swedish above 2300 in 566 genera, and the Lapponian 1100 species in 297 genera; the French flora, therefore, gives an average of 6, the Swedish 4.1, the Lapponian 3.6 species to a genus.

With regard to the conditions of distribution of the primary divisions of the vegetable kingdom, it would appear, from Humboldt's researches, that the proportion of the Cryptogamia to the Phanerogamia increased with the distance from the equator, since he represents the numbers as equal in the latitudes 67°—70°, the Cryptogamia one-half less in 45°—52°, and scarcely forming one-eighth in 0°—10°—the proportion being there one-fifteenth for the plains and one-fifth for the mountains—the latter proportion evidently corroborating the deductions on the ground of the correspondence between increased altitude and increased latitude. But, on consideration, it becomes evident that our data are insufficient at present to allow us to generalise safely as to the distribution of the Cryptogamia, which, from their ordinarily inconspicuous nature, are the last to be thoroughly investigated in any country, and consequently must be far better known in the well-examined countries of Europe, or in the meagre floras of the frigid zone, where every sign of vegetation is an attraction, than in the richly clothed tropics, where, as we have seen, even unknown lofty trees are by no means unfrequently met by the botanist in tracts already often gleaned, and where vast extents of forest and marsh have never yet been explored.

Comparing the two great divisions of the flowering plants, the Monocotyledons seem to bear a higher proportion to the Dicotyledons in proportion to the distance from the equator. From 0° to 10° they form about one-sixth of the entire number of Phanerogamia, in the New World, and about one-fifth in the Old. Increasing progressively, they form about one-fourth towards the middle of the temperate zone, and about one-third towards its limit. But the proportion sinks again a little in the glacial regions—as, for example, in Greenland.

These proportions depend upon the increase of certain families and the decrease of others; some of which variations, as given by Humboldt, may be here indicated:—

1. The group of Glumaceæ, which is made to include the rushes (Juncaceæ), as well as the sedges (Cyperaceæ), and grasses (Gramineæ), increases from the equator towards the poles, forming under the tropics one-eleventh, in the temperate zone one-eighth, and in the frigid zone one-fourth of the whole phanerogamic or flowering vegetation.

The increase towards the poles is given by the rushes and sedges, which are comparatively rare in the warmer regions. The Juncaceæ alone almost disappear within the tropics, forming only one-four-hundredth of the Phanerogamia, while, in the temperate zone, they form one-ninetieth, and in the frigid zone one-twenty-fifth. The Cyperaceæ form, under the tropics, in the New World one-fiftieth, in the Old World one-twenty-second, in the temperate zone one-twentieth, and in the frigid zone one-ninth.

The Gramineæ are pretty equally distributed over the whole earth, increasing in a small degree towards the poles; between the tropics the Grasses form one-fourteenth, in the temperate zone one-twelfth, and in the frigid zone one-tenth of the flowering plants.

These families increase in number of individuals from the equator towards the poles.

The Ericaceæ, or heath-like plants, also increase from the equator to the poles, forming one-hundred-and-thirtieth under the tropics in America, one-hundredth in the temperate zone of the Old World, one-thirty-sixth in that of the New World, and in the frigid zone one-twenty-fifth.

The Amentaceæ, or catkin-bearing plants, of which the oak, beech, birch, and most other timber trees of temperate regions, are members, form only one-eight-hundredth part of the species of flowering plants in the torrid zone, one-forty-fifth in the temperate zone of Europe, one-twenty-fifth in that of North America, and in the frigid zone make up one-twentieth of the phanerogamic flora.

2. Four other families have their maximum of species in the torrid zone; viz., the Leguminosæ, the Rubiaceæ, the Euphorbiaceæ, and the Malvaceæ.

The Leguminosæ form under the tropics one-tenth, in the temperate zone one-eighteenth, and in the frigid zone one-thirty-fifth of the species of Phanerogamia.

The Rubiaceæ, under the tropics of the Old World, one-fourteenth, of the New World one-twenty-fifth; in the temperate zone one-sixtieth, and in the frigid zone one-eightieth. The Coffeæ form one-third of the Rubiaceæ of tropical America, while the Stellatæ belong principally to the temperate climates.

The Euphorbiaceæ, in the torrid zone, one-thirty-second, in the temperate one-two-hundredth, and in the frigid zone one-five-hundredth.

The Malvaceæ, in the torrid zone, one-thirty-fifth, in the temperate zone one-two-hundredth, and in the frigid zone none are met with.

3. These families have their maximum in the temperate zone, the number of species diminishing both towards the equator and towards the poles; viz., the Compositæ, the Cruciferæ, the Labiatæ, and the Umbelliferæ.

The Compositæ form, under the tropics of the Old World, one-eighteenth, of the New World one-twelfth, in the temperate zone of Europe one-eighth, of America one-sixth, and in the frigid zone one-eighteenth of the Phanerogamia.

The Cruciferæ are almost unknown in the torrid zone, taking the mountain regions between 8000 and 11,000 feet, where they form scarcely one-eight-hundredth of the flowering plants. In the temperate zone in Europe they make up one-nineteenth (in America only one-sixtieth), in the frigid zone one-twenty-eighth.

The Labiatæ form, under the tropics, one-fortieth, in the temperate zone of Europe one-twenty-fifth, in America one-fortieth, in the frigid zone one-seventieth.

The scarcity of the Labiatæ, as well as of the Cruciferæ, in the temperate zone of America, is a remarkable circumstance.

The Umbelliferæ are seldom met with in the tropics below an elevation of 8000 feet; above this elevation they form (excluding the very few species of the plains) only one-five-hundredth, of the Phanerogamia. In the temperate zone they form one-fortieth, being also more numerous in Europe than in North America; in the frigid zone they form one-sixtieth.

Among the flowerless plants, the Ferns decrease from the equator towards the poles, warmth combined with moisture being most favourable to them. Under the tropics they form one-twentieth, in the temperate zone one-seventieth part of the number of all flowering plants. They are entirely deficient in Arctic America.

The following series of numerical proportions of particular countries, confessedly fragmentary, may serve to elucidate to some extent the special conditions which produce the general relations dwelt upon above:—

LAPLAND.
(Fries.)

Species—Monocotyledons 228 + Dicotyledons 469 = 697. *Genera*—283. *Families*—72.

Cyperaceæ 1-8, Gramineæ nearly 1-10, Juncaceæ 1-27, Orchidaceæ 1-36, Compositæ 1-10, Cruciferæ 1-21, Caryophyllaceæ 1-22, Salicineæ 1-23, Rosaceæ 1-23, Ranunculaceæ 1-27, Scrophulariaceæ 1-32, Leguminosæ 1-36, Ericaceæ 1-36, Saxifragaceæ 1-48, Labiatæ 1-52, Umbelliferæ 1-52.

NORWAY.
(Fries.)

Species—1200. *Genera*—404. *Families*—84.

Cyperaceæ 1-11¼, Gramineæ 1-12½, Juncaceæ 1-46, Orchidaceæ 1-48, Compositæ 1-10, Rosaceæ 1-18, Cruciferæ 1-21, Caryophyllaceæ 1-21, Leguminosæ 1-25, Scrophulariaceæ 1-28, Umbelliferæ 1-32, Labiatæ 1-33, Salicineæ 1-36, Ericaceæ 1-52, Boraginaceæ and Polygonaceæ each 1-57.

SWEDEN.
(Fries.)
North of the Lakes.

Species—Monocotyledons 312 + Dicotyledons 944 = 1256.

Gramineæ 1-13, Cyperaceæ 1-13, Juncaceæ 1-44, Orchidaceæ 1-44, Compositæ 1-12, Rosaceæ 1-20½, Cruciferæ 1-22½, Caryophyllaceæ 1-25, Scrophulariaceæ 1-26, Leguminosæ 1-27, Ranunculaceæ 1-30, Salicineæ 1-33, Labiatæ 1-37, Umbelliferæ 1-38, Ericaceæ 1-63, Boraginaceæ 1-74.

South of the Lakes, Gothland.

Species—Monocotyledons 347 + Dicotyledons 1069 = 1416.

Gramineæ 1-12, Cyperaceæ 1-15½, Orchidaceæ 1-40, Juncaceæ 1-68, Compositæ 1-11¼, Rosaceæ 1-16, Leguminosæ 1-19¼, Cruciferæ 1-22½, Caryophyllaceæ 1-23½, Scrophulariaceæ 1-25, Umbelliferæ 1-27, Labiatæ 1-28, Ranunculaceæ 1-29, Salicineæ 1-44, Boraginaceæ 1-70, Ericaceæ 1-83.

FINLAND.
(Fries.)

Species—Monocotyledons 262 + Dicotyledons 704 = 966.

Cyperaceæ 1-11, Gramineæ 1-12½, Orchidaceæ 1-37, Juncaceæ 1-56, Compositæ 1-11¼, Cruciferæ 1-18, Rosaceæ 1-20½, Scrophulariaceæ 1-20½, Caryophyllaceæ 1-21, Leguminosæ 1-25, Ranunculaceæ 1-26, Labiatæ 1-32, Umbelliferæ 1-36, Salicineæ 1-37, Ericaceæ 1-48, Boraginaceæ 1-51.

ICELAND.
(Vahl and Babington.)

Species—Monocotyledons 132 + Dicotyledons 282 = 414.

Cyperaceæ almost 1-9, Gramineæ 1-9½, Orchidaceæ 1-35, Potameæ 1-38½, Compositæ 1-17, Caryophyllaceæ 1-18, Cruciferæ 1-19, Salicineæ 1-24, Ericaceæ 1-26, Saxifragaceæ 1-26, Rosaceæ about 1-28, Scrophulariaceæ 1-32, Ranunculaceæ 1-38½, Polygonaceæ 1-38½, Leguminosæ 1-46, Rubiaceæ 1-46, Onagraceæ 1-46, Gentianaceæ 1-46, Labiatæ 1-59, Umbelliferæ 1-59. (Out of 50 families, 16 are represented by a single species.)

GREAT BRITAIN.
(H. C. Watson.)

Species—Monocotyledons 340 + Dicotyledons 1031 = 1371. *Genera*—503. *Families*—86.

Gramineæ 1-12½, Cyperaceæ 1-16, Orchidaceæ 1-40, Juncaceæ 1-53, Compositæ 1-10½, Cruciferæ 1-19½, Leguminosæ about 1-21, Umbelliferæ 1-22, Caryophyllaceæ 1-25½, Scrophulariaceæ 1-25½, Rosaceæ 1-26, Labiatæ 1-28½, Ranunculaceæ 1-39, Salicineæ 1-41, Boraginaceæ 1-57, Ericaceæ 1-60.

FRANCE.
(Martins.)

Species—Monocotyledons 713 + Dicotyledons 2950 = 3660.

Gramineæ 1-13, Cyperaceæ 1-29, Orchidaceæ 1-64, Juncaceæ 1-89, Compositæ 1-8, Leguminosæ 1-10½, Cruciferæ 1-18, Umbelliferæ 1-20½, Caryophyllaceæ 1-24, Labiatæ 1-25, Ranunculaceæ 1-28, Rosaceæ 1-30.

GERMANY.
(Koch.)

Species—Monocotyledons 529 + Dicotyledons 2037 = 2566. *Families*—115.

Gramineæ about 1-15, Cyperaceæ 1-18, Orchidaceæ 1-53½, Juncaceæ 1-85½, Compositæ 1-8, Leguminosæ 1-17, Cruciferæ 1-17, Scrophulariaceæ 1-21½, Umbelliferæ 1-22½, Caryophyllaceæ 1-22½, Ranunculaceæ 1-28½, Labiatæ 1-29, Rosaceæ 1-29, Salicineæ 1-53½.

LOMBARDY.
(Cesati.)

Species—Monocotyledons 514 + Dicotyledons 2054 = 2568. *Families*—129.

Gramineæ 1-13½, Cyperaceæ 1-22½, Orchidaceæ 1-47, Juncaceæ 1-69, Compositæ 1-8, Leguminosæ 1-14, Cruciferæ 1-20, Umbelliferæ 1-23, Caryophyllaceæ 1-24, Scrophulariaceæ 1-24, Labiatæ 1-26, Rosaceæ 1-28, Ranunculaceæ 1-29, Salicineæ 1-83.

THE MOREA.
(Bory St Vincent.)

Species—Monocotyledons 260 + Dicotyledons 1085 = 1345. *Families*—91.

Gramineæ not quite 1-15, Cyperaceæ 1-39, Orchidaceæ 1-40, Leguminosæ 1-9, Compositæ 1-10, Labiatæ 1-20, Cruciferæ not quite 1-20, Caryophyllaceæ 1-24, Umbelliferæ 1-27, Ranunculaceæ rather more than 1-35, Boraginaceæ 1-42, Scrophulariaceæ 1-43, Rosaceæ 1-44.

SPAIN.

Reuter's Collection of 1250 Species from New Castile gave the following proportions:—

Gramineæ 1-10, Compositæ 1-8½, Leguminosæ 1-11¼, Cruciferæ 1-16½, Caryophyllaceæ 1-20½, Labiatæ 1-23¼, Scrophulariaceæ 1-24, Rosaceæ 1-33, Boraginaceæ 1-33, Ranunculaceæ 1-38.

NORTHERN UNITED STATES.
(Asa Gray, 1848.)

Species—Monocotyledons 571 + Dicotyledons 1395 = 1966. *Genera*—720. *Families*—129.

Cyperaceæ 1-9¼, Gramineæ 1-12, Orchidaceæ 1-40, Compositæ 1-7½, Rosaceæ 1-22, Leguminosæ 1-24, Labiatæ 1-30, Ericaceæ 1-36, Scrophulariaceæ 1-38½, Cruciferæ 1-42, Ranunculaceæ 1-42, Caryophyllaceæ 1-48, Umbelliferæ 1-49, Salicineæ 1-68, Cruciferæ 1-109.

BRITISH GUIANA.
(Richard Schomburgk.)

Species—Monocotyledons 751 + Dicotyledons 2503 = 3254. *Genera*—about 920. *Families*—146.

Orchidaceæ 1-15, Cyperaceæ 1-27, Gramineæ 1-31, Palmæ 1-56, Bromeliaceæ 1-120, Leguminosæ 1-8½, Rubiaceæ 1-18, Melastomaceæ 1-26, Compositæ 1-31, Euphorbiaceæ 1-37½, Apocynaceæ 1-42, Malpighiaceæ 1-46½, Myrtaceæ 1-51½, Piperaceæ 1-53, Convolvulaceæ 1-69, Malvaceæ 1-75½, Bignoniaceæ 1-81, (Filices 228 species).

GALLAPAGOS ISLANDS.
(J. D. Hooker.)

Species—Monocotyledons 22 + Dicotyledons 203 = 225. *Families*—53.

Gramineæ 1-20, Compositæ 1-8, Leguminosæ 1-9½, Euphorbiaceæ 1-11, Rubiaceæ 1-15, Solanaceæ 1-17, Amaranthaceæ 1-23, Caryophyllaceæ 1-112½, Cruciferæ 1-225.

CANARY ISLANDS.
(Webb and Berthelot.)
About 900 species.

Cyperaceæ 1-50, Liliaceæ 1-39, Compositæ 1-9½, Leguminosæ 1-8½, Labiatæ 1-15½, Cruciferæ 1-30, Crassulaceæ 1-31, Caryophyllaceæ 1-31, Euphorbiaceæ 1-36, Ranunculaceæ 1-75.

WESTERN TROPICAL AFRICA—UPPER GUINEA, 0°—10° N.L., including FERNANDO PO.
(Niger Flora, 1849.)

Species—Monocotyledons 297 + Dicotyledons 953 = 1250. *Genera*—About 480. *Families*—133.

Gramineæ 1-10, Cyperaceæ 1-20, Orchidaceæ 1-46, Commelynaceæ 1-64½, Palmæ 1-208, Leguminosæ 1-8, Rubiaceæ 1-11, Euphorbiaceæ 1-26½, Compositæ 1-28½, Acanthaceæ 1-30½, Convolvulaceæ 1-40, Urticaceæ 1-43½, Malvaceæ 1-44½, Melastomaceæ 1-54, Amaranthaceæ 1-60, Apocynaceæ 1-66, Cucurbitaceæ 1-69, Ampelidaceæ 1-69, Capparidaceæ 1-74.

SOUTH AFRICA.
(According to Meyer's tables of Drège's Collections.)

Species—Monocotyledons 1586, + Dicotyledons 5009 = 6595. *Genera*—1008. *Families*—143.

Gramineæ 1-21, Iridaceæ 1-24, Restiaceæ 1-34, Cyperaceæ 1-36, Compositæ 1-6, Leguminosæ 1-13, Scrophulariaceæ 1-38, Geraniceæ 1-39, Ericaceæ 1-39, Proteaceæ 1-42, Umbelliferæ 1-63, Cruciferæ 1-76, Labiatæ 1-83, Rosaceæ 1-93.

EAST INDIES.
(According to Martius's *Summary* of Wallich's *Herbarium*, 1828.)

Species—Monocotyledons 918 + Dicotyledons 6036 = 6954. *Families*—About 180.

Gramineæ about 1-57, Cyperaceæ 1-29½, Orchidaceæ 1-31, Leguminosæ 1-9, Compositæ 1-16, Acanthaceæ 1-23½, Rubiaceæ 1-26½, Labiatæ 1-35, Ampelidaceæ 1-41, Verbenaceæ 1-42, Malvaceæ 1-44, Myrtaceæ 1-44, Umbelliferæ 1-114, Cruciferæ 1-302, Salicineæ 1-496.

AUSTRALIA.
(Preiss's Collection.)

Species—Monocotyledons 491 + Dicotyledons 1420 = 1910.

Gramineæ 1-48½, Cyperaceæ 1-33, Orchidaceæ 1-39, Hæmadoraceæ 1-42, Juncaceæ 1-388, Leguminosæ 1-8, Proteaceæ 1-9, Myrtaceæ 1-12, Compositæ 1-19, Epacridaceæ 1-20, Stylideæ 1-28, Goodenovieæ 1-33, Cruciferæ 1-242, Ranunculaceæ 1-323, Scrophulariaceæ 1-323, Boraginaceæ 1-380.

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PLATE 26

ZOOLOGICAL GEOGRAPHY.

THE GEOGRAPHICAL DIVISION AND DISTRIBUTION OF MAMMIFEROUS ANIMALS,

OF THE ORDERS

QUADRUMANA, MARSUPIALIA, EDENTATA, AND PACHYDERMATA.

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GENERAL INTRODUCTION.

It has long been observed that certain tribes, genera, and species of animals, are peculiar to certain regions of the globe, and an investigation into the manner of their distribution, or an inquiry concerning the laws affecting their geographical arrangement, has ever been regarded as constituting, in itself, an interesting subject of research, and forming a necessary adjunct to a complete understanding of the nature and extent of the animal kingdom. The accomplishment of this, in so far as it is attainable in the present limited state of our knowledge of animal life, is the object of this division of the Physical Atlas. As, by comparing the flora of a particular country or district with that of an extensive zone or quarter of the earth, we are enabled to mark its peculiarities, and ascertain in how far it harmonizes with the character of the entire vegetation; so we shall find, that by following a similar method in examining the fauna of a given district or zone, we are led to equally interesting results. By such researches modern science has established the singular and unexpected phenomenon of the division of the globe into different and distinct regions or nations of plants and animals. In some respects the distribution of animals resembles that of plants; the limits of both are, in so far, circumscribed by the intervention of seas, and continuous chains of mountains, yet both are chiefly influenced by the inequalities of temperature. Animal life is most intimately connected with, and dependent upon, the vegetable kingdom; heat and moisture stimulate the growth of plants, therefore the greater the amount of these atmospheric phenomena, so much more luxuriant is vegetation, and so much more abundant are animal formations. Hence we find, as a general rule, that vegetation is most exuberant, and animals most prolific, in the countries under the tropics, where heat is greatest, and moisture most abundant. As these decrease in a direction from the equator towards the poles, so, and perhaps in a similar proportion, do animals decrease, not only in the size of individuals, but also in the number of species. This law affects all animals, the vertebrated as well as the invertebrated, in so far as they are inhabitants of the land, but it is reversed in the case of those of higher organization which inhabit the sea; the latter (as explained in the notes to Map No. 2 of this division) being found to *increase* in a direction from the equator towards the poles.

We have here an interesting example of the connection and harmony that subsist between the different branches of natural science; we see the dependence of animal upon vegetable life, and of both on meteorology.

As animals, like plants, are adapted to particular climatic conditions, like them also they are subjected to invariable laws; for, though man can bear with equal impunity the burning heat of the tropics, or the intense cold of the frozen zone, yet he has not succeeded in rendering animals cosmopolite. Of all vertebrated animals, the dog alone is enabled to accompany man in all his migrations. Many others cannot exist except under the influence of a determinate climate; they pass not the limits which the Author of the universe has fixed as the bounds of their habitation. The polar bear could not live under the scorching rays of a vertical sun, nor could the lion or the tiger long survive the rigours of an arctic winter.

"Thus the apes which multiply in the tropical regions almost always die of phthisis, when exposed to the humidity of our climates; whilst the rein-deer, adapted by nature to support the long and severe winters of Lapland, suffers from the heat of St Petersburg, and sinks rapidly under the influence of a temperate climate. It results from this, that in a majority of cases the difference of climate is sufficient of itself to arrest the species in their progress from higher latitudes towards the equator, or from the equatorial regions towards the poles."[1] Nor is this law confined, in its operation, to distant and dissimilar regions of the globe—we find it affecting the fauna of different parts of the same continent; thus Mr Lyell, in his recent travels in North America, observes there are "several distinct zones of indigenous Mammalia extending east and west on this continent, where there are no great natural boundaries running in the same direction, such as mountain ridges, deserts, or wide arms of the sea, to check the migrations of species. The climate alone has been sufficient to limit their range. The mammiferous fauna of New York, comprising about forty species, is distinct from that of the arctic region six hundred miles north of it, and described by Dr Richardson. It is equally distinct from that of South Carolina and Georgia, a territory about as far distant to the south."[2]

The difference between a coast and a continental climate is also exemplified in the decrease of vegetable and animal life in proportion as we recede from the coasts, and approach the interior of continents. In the arid plains of the interior, vegetation loses its luxuriance, and, consequently, its power to maintain the numerous tribes of animals which depend for subsistence on the leaves and plants peculiar to a humid soil.

The analogy between vegetable and animal geography is not less apparent when we consider the distribution of the latter in a perpendicular as well as in a horizontal direction. "The Himalaya, with a temperature varying from the heat of the equator to that of the poles, presents an epitome of the Mammalogy of the world—a succession of species similar to that which we meet in travelling from India to Kamtchatka, or from Brazil to Labrador. The *Thibetan Musk* is found on the mountains in the vicinity of the snow. The antelope *Ghoral*, *A. than*, and *A. Hodgsonii*, peculiar to these mountains, are generally found on the most inaccessible places in the warm weather; but in the colder, like most other animals, they come down to lower elevations for the benefit of a milder climate and better pasturage."—"The *Pika*, like the *Arvicola*, lays up a winter store, and continues to thrive in a climate apparently incompatible with animal existence."[3]

The influence of temperature on the animal economy explains the reason why certain species remain shut up within a chain of mountains, without being able to spread themselves to similar localities in other mountainous districts. For as temperature decreases with the elevation of the soil, animals which live at considerable heights cannot descend into the plains, in order to arrive at other mountains, without traversing countries the temperature of which is much higher than that to which they are accustomed. The llama, for example, as Humboldt remarks, abounds in the pasture-lands of Peru and Chile, situated at an elevation of from 13,000 to 16,000 feet above the level of the sea, and extends thence to the extremity of Patagonia; but is not known either in Brazil or Mexico, because it could not arrive there without descending to regions too warm for its constitution. Many hypotheses have been advanced to account for the present distribution of animals over the surface of the globe; but on this subject we are not called upon to enter, and shall only remark, that there is abundant evidence, in the wonderful adaptation of the structure of animals to the circumstances in which they are placed, to convince even the most casual observer that this arrangement is the result of design, and that they have been so placed by the Author of the universe as a part of "the great symmetrical whole of creation."

Zoological Geography is that part of our science which treats of the habitats, the limits of distribution and dispersion of animals as they at present exist, as well as the varieties of animal life considered in relation to external circumstances.

In order to exhibit the vast field of view thus opened up to the inquirer, we subjoin the following table of the great leading divisions of the animal kingdom, according to Cuvier's classification, which forms generally the basis of these representations of zoological geography, except in cases where numerous discoveries since his time have rendered a different arrangement necessary, as in the case of the Marsupialia, of which our knowledge has been so greatly increased within a few years.

In 1829, Winding reckoned the number of species of Mammalia at 1,230; Charles Bonaparte, in 1832, at only 1,149; but Oken is of opinion that the probable number may be assumed to be 1,500. We have, therefore, taken this last as the basis of our calculations in ascertaining the proportionate numbers of the species.

TABLE OF CLASSIFICATION OF THE ANIMAL KINGDOM ACCORDING TO CUVIER (1829).

DIVISION I.—VERTEBRATA.

WITH AN INTERNAL BONY SKELETON AND VERTEBRAL COLUMN.

MAMMALIA, With Mammæ, and producing living young	Bimana	*Two-handed*	Man
	Quadrumana	*Four-handed*	Apes
	Cheiroptera	*Wing-handed*	Bats
	Insectivora	*Insect-eaters.*	Mole, hedgehog
	Carnivora	*Flesh-eaters*	Lion, dog, bear
	Amphibia	*Amphibious*	Seal, morse
	Marsupialia	*Pouched*	Opossum, kangaroo
	Rodentia	*Gnawers*	Squirrel, mouse, hare
	Edentata	*Toothless*	Sloth, ant-eater
	Pachydermata	*Thick-skinned*	Elephant, horse, tapir
	Ruminantia	*Ruminants*	Camel, ox, deer, sheep
	Cetacea	*Ocean-living*	Whale, dolphin, narwal
AVES, Bipeds, winged and oviparous	Rapaces	*Birds of prey*	Vulture, eagle, condor, owl
	Scansores	*Climbers*	Woodpecker, kingfisher, cuckoo
	Oscines	*Songsters*	Thrush, lark, swallow, crow
	Gallinaceæ	*Poultry*	Fowl, pigeon, turkey, partridge
	Grallatores	*Waders*	Stork, heron, plover, snipe
	Natatores	*Swimmers*	Duck, pelican, tern
REPTILIA, Cold-blooded	Testudines	*Shielded*	Tortoise, turtle
	Sauria	*Lizards*	Crocodile, chamelion
	Ophidia	*Serpents*	Boa, viper, coluber
	Amphibia	*Frogs*	Toad, frog, siren
PISCES, Aquatic, with gills	Acanthopterygii	*Spiney fins*	Perch, sturgeon, mullet
	Malacopterygii	*Soft-finned*	Salmon, carp, cod
	Lophobranchii	*Tufted gills*	Pegasus, hippocampus
	Plectognathi	*Satured cheeks*	Sunfish, porcupine fish
	Chondropterygii	*Cartilaginous*	Sturgeon, shark, skate

DIVISION II.—MOLLUSCA.

SOFT-BODIED ANIMALS, WITHOUT A SKELETON, MOSTLY SHELL-COVERED AND AQUATIC.

CEPHALOPODA	*Arms about the mouth*	Cuttle, nautilus
PTEROPODA	*Wing-footed*	Clio, hyalea
GASTEROPODA	*Belly-creepers*	Snail, limpet
ACEPHALA	*With no distinct head*	Oyster, muscle
BRACHIOPODA	*Arm-footed*	Lingula terebratula

DIVISION III.—ARTICULATA.

WITH JOINTED BODIES.

ANNULATA	Tubicula	*Tube-covered*	Serpula, terebella
	Dorsibranchiata	*Gills on the back*	Nereis, aphrodita
	Abranchiata	*Without gills*	Earth-worm, leech
CRUSTACEA	Malacostraca	*With soft shells*	Crab, lobster
	Entomostraca	*With thin shells*	Monoculus [of Cuvier
CIRRHOPODA	*Brush-footed*	Barnacle, balanus	Removed from Division II.
ARACHNIDES	Pulmonaria	*With lungs*	Spider, mygale
	Trachearia	*With spiracles*	Tarantula, scorpion, mite
INSECTA	Myriopoda	*Many-footed*	Centipede, julus, scolopendron
	Thysanoura	*With fringed tail and wingless*	Lepisma, Podura
	Parasita	*Parasites and wingless*	Louse
	Suctoria	*With proboscis and wingless*	Flea
	Coleoptera	*Hard outer wings*	Beetles
	Orthoptera	*Straight long wings*	Locust, earwig
	Hemiptera	*Half membranous wings*	Aphis, bug
	Neuroptera	*Four network wings*	Dragon-fly, ephemera
	Hymenoptera	*Four membranous wings*	Bee, ant, ichneumon
	Lepidoptera	*Scaley wings*	Butterfly, moth
	Rhipiptera	*Fan-winged*	Stylops, xenos
	Diptera	*With two membranous wings*	Fly, gnat

DIVISION IV.

WITH A CIRCULAR RADIATING NERVOUS SYSTEM; AND THE ZOOPHYTA, PLANT-LIKE ANIMALS.

ECHINODERMATA	Pedicellata	*With numerous spines*	Star-fish, sea-urchin
	Apoda	*Without spines*	Siphunculus, lithodermis
ENTOZOA	Nematoidea	*Thread-like*	Ascaris, guinea-worm
	Parenchymata	*A cellular sac*	Hydatid, tape-worm
ACALEPHA	Simplicia	*Nettle-like*	Medusa
	Hydrostatica		Physalia
POLYPI	Carnosi	*Many-footed*	Actinia
	Gelatinosi		Hydra, verticella
	Coralliferi		Tubipore, sertularia, alcyonium
INFUSORIA	Rotifera	*Infusory animalcules*	Wheel animal
	Polygastrica		Monad volvox

When we consider the foregoing classification of the distribution of animal life over the globe, it is evident that its chartographic treatment and representation has to contend with peculiar and very serious difficulties, occasioned chiefly by the great diversity of animals—the representation of which would require a vast number of maps. Hence, in this first attempt at chartographic zoology, and in our limited space, we can only give outlines of the geographical distribution of particular divisions of the animal world, with a view of calling attention to the interesting nature of the study of animal geography, and to stimulate to further researches and investigations those who are engaged in the pursuit of this branch of the physical description of the earth.

The occurrence of a class of animals in a particular country or region is indicated on the map by shading, which is darker in proportion to the number of species existing in it. Thus, for example, in the map of the Quadrumana, the shading indicates that the animals of this order inhabit the southern countries of Asia, nearly all Africa, and a great part of South America; while the depth of shading shows that they occur in greatest numbers in the tropical regions of those countries. Again, in the map of the Marsupialia, it is shown that no animals of this order occur in Asia or Africa, and that the greatest number of species is found in Australia.

Besides this general view of the distribution of animals, we have attempted to define, by means of coloured lines on the different maps, the limits of the most important and characteristic species of each of the different families and genera. This has been attended with difficulties which, in many cases, have proved insurmountable. In this respect, botanical has a great advantage over zoological chartography; rest is the characteristic of vegetable, while motion is the attribute of animal life. With comparative ease the botanist may examine the stations of plants, and ascertain the place where they cease to grow; but the case is very different with the zoologist, who has to pursue the fugitive animal, as circumstances may require, through field or forest, over the verdant meadow or through the dreary wilderness, and must be content to arrive at a knowledge of its habitat from indirect and often vague and unsatisfactory sources. It cannot be expected, therefore, that the boundaries marked on the map should strictly define the range of every particular animal; for that would be to demand from this method of representation an amount of information which, in the present state of our knowledge of animal life, it is impossible to attain.

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[1] Milne Edwards.

[2] Lyell's Travels in North America, vol. i. p. 172.

[3] Royle. Illustrations of the Botany and other branches of the Natural History of the Himalayan Mountains.

DESCRIPTION OF THE MAP.

This sheet is divided into three compartments, comprising four maps of the geographical division and distribution of

1. Quadrumana, Four-handed Mammalia.
2. Marsupialia, Pouched Mammalia.
3. Edentata, Toothless Mammalia.
4. Pachydermata, Thick-skinned Mammalia.

FIRST SECTION.

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF THE *QUADRUMANA (FOUR-HANDED MAMMALIA)* COMPRISING: *SIMIAE (MONKEYS)* AND *PROSIMIAE (MAKIS)*.

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

The monkeys are divided into two families: 1, *Simiae catarrhini*; 2, *Simiae platyrrhini*. Simiae catarrhini, monkeys with oblique and very wide-set nostrils, and a human-like system of teeth, are found only in the Old World; and Simiae platyrrhini, monkeys with nostrils placed at the side, and wide asunder, and with three false grinders on each side of both jaws, occur only in the New World. The monkeys contain in all 170 species, forming one-ninth of all Mammalia.

Simiae catarrhini (the monkeys of the Old World), comprising in all 79 species, or one-nineteenth of all Mammalia, are arranged in the following two groups and eleven genera :—

I. Tailed monkeys, = 72 species.

1. Cynocephalus (Baboons), . .	23 species.
2. Inuus (Magots), ...	3 „
3. Macacus (Macacos), . . .	9 „
4. Colobus (Thumbless apes), .	7 „
5. Cercopithecus (Guenons), . .	17 „
6. Presbytis (Tailed Gibbons), .	1 species.
7. Semnopithecus (Solemn apes), .	12 „

II. Tailless monkeys, = 7 species.

1. Hylobates (Gibbons or long-armed apes), ...	5 „
2. Simia (Orangs), ...	2 „

Simiae platyrrhini (the monkeys of the New World), comprising in all 91 species, or one-sixteenth of all Mammalia, consist likewise of two groups and nine genera :—

I. Sapajes (Sapajous), = 43 species.

1. Mycetes (Howlers, or howling apes),	9 species.
2. Ateles (Spider monkeys), . .	9 „
3. Lagothrix (Gluttonous monkeys), .	2 „
4. Cebus (Sapajous or Weepers), .	23 „

II. Sajuins (Sajouins), = 48 species.

1. Pithecia (Sakis or Fox-tails), .	12 species.
2. Callithrix (Squirrel monkeys),	11 „
3. Nyctipithecus (Night monkeys),	3 „
4. Hapale (Ouistitis) or Marmousets),	10 „
5. Midas (Tamarins) or Marmousets),	12 „

The *second family*, or that of PROSIMIAE (MAKIS), consist of 32 species, or one-forty-seventh of all Mammalia, which are divided among the individual genera in the following manner :—

1. Lemur (Lemurs), ...	14 species.
2. Lichanotus (Indris), . . .	2 „
3. Stenops (Lorises), . . .	6 „
4. Otolicnus (Galagoes) . .	4 species.
5. Tarsius (Tarsiers), ...	6 „

The Quadrumana differ from man, to whom, of all animals, they bear the nearest corporeal resemblance, especially in this, that they inhabit only a particular portion of the globe, whilst the human race is (with the exception of some polar deserts) spread over the whole earth, and in this respect can hardly be said to have any limits. The torrid regions, both of the Old and New World, constitute the dwelling-place of monkeys. The whole of Africa, except Egypt, is occupied by them, from the Cape of Good Hope to the Strait of Gibraltar; here the Turkish or Barbary ape, *Inuus sylvanus s. ecaudatus*, a magot, is remarkable as the only one of its family which, quitting its native country, is found within the geographical limits of Europe, being still abundant on the Rock of Gibraltar, latitude 37° north. In an equally high latitude, on the eastern border of the Old World, another magot, *Inuus speciosus*, is found in the Island of Niphon. But the true native country of the Asiatic ape is India, the continent, including the southern part of China, as well as, and indeed more especially, the Archipelago, to the meridian of the east end of Timor. This island, as well as Celebes, forms, with the Philippines, the eastern limit of the distribution of apes in the torrid zone of the Old World. Beyond this no apes are found; for in the west Australian islands, the continent of Australia and the islands of Polynesia, four-handed quadrupeds are unknown.

But in America they again appear, and occupy almost the entire half of this part of the earth, from Honduras, latitude 16° north, to beyond the pampas of Buenos Ayres, latitude 38° south. Here, in the New World, consequently, the distribution of apes is confined to a space of 54°, whilst in the Old World, between Gibraltar and the Cape of Good Hope, it extends to 72° of latitude, and on both sides of the Atlantic. Their favourite resort is in the table-lands covered with primitive forests.

DIVISION AND INTENSITY OF THE SINGLE SPECIES.

In the following table we have represented the division of each single genus of the monkeys and makis, in the different regions of the Old and New World, according to the number of their species. On the map the same information is conveyed graphically, by means of shading, so that where the shading is darkest the number of species is greatest. In this table we have selected those countries in which the species present the greatest characteristic distinctions; and, therefore, the political divisions are not so much attended to as the physical boundaries of countries; thus, for example, in the valleys of Hindustan more monkeys occur than in the table-land of the Deccan, and accordingly these districts are separated in the table. It must be observed, however, that the greater or less apparent density in the several regions must depend, in part, on the more or less accurate observations that have been made in them. The banks of the Orinoco and Magdalena, in South America, for example, having been thoroughly explored, may appear to have a greater number of species than other districts which, not having had this advantage, are, on account of this uncertainty, not so deeply shaded. Yet, we may observe at a glance, that the apes are concentrated in the countries under the equator, and that there they attain their maximum. Of the three equatorial regions of Asia, Africa, and America, that of America (Brazil) has by far the greatest number of species, the amount being nearly double that of the continents of the Old World. Probably the greatest number of species of apes occur in the selvas—the immense wooded plains on the banks of the Amazon River; from this they extend to the eastern declivity of the Andes, but very seldom pass over them, since, on the whole western side of the Cordilleras, from Panama to Chile, one species only, the *Ateles pentadactylus* (five-fingered spider monkey) occurs in Peru, where the *Ateles melanochir* (black-headed spider monkey) is also said to be found. As the maximum of all the apes of the New World are found in Brazil, so also the maximum of each single genus occurs there; there being only one genus in Guayana—that of the cebus (weepers), —which has one species more.

Of the nine genera of *monkeys in the Old World*, five belong to both continents of Asia and Africa, namely, the baboons, magots, macacos, and guenons, of the group of the *tailed monkeys*, and the orangs, of the group of the *tailless monkeys*.

The baboons occur in greatest numbers in tropical Africa. Of the genus of the magots, none of the districts contain more than one species. The macacos are most numerous in Hindustan, and the guenons on the western coast of Africa, where all the species except two are found. Of the two species of the orangs, one occurs in the tropical Archipelago of Asia, and the other in tropical Africa. Besides these five genera common to both continents, there are three which occur only in Asia and one in Africa, these are the tailed and the proper gibbons, which are most numerous in the Island of Sumatra and the peninsula of Malacca; and the solemn apes, which occur in greatest numbers on the islands of Borneo, Sumatra, and Java. The thumbless apes in Africa, representing the solemn apes of Asia, are most numerous in tropical Africa.

The Island of Madagascar is the chief habitat of the makis :—

TABLE SHOWING THE DIVISION OF *SIMIAE* AND *PROSIMIAE* (*MONKEYS* AND *MAKIS*), OVER THE GLOBE, ACCORDING TO THE NUMBER OF THEIR SPECIES.

I. SIMIAE CATARRHINI (MONKEYS OF THE OLD WORLD.)

REGIONS AND COUNTRIES. (From North to South.)	*a*, TAILED MONKEYS.								*b*, TAILLESS MONKEYS.			
	1. Cynocephalus (Baboons.)	2. Inuus (Magots.)	3. Macacus (Macacos.)	4. Colobus (Thumbless apes.)	5. Cercopithecus (Guenons.)	6. Presbytis (Tailed gibbons.)	7. Semnopithecus (Solemn apes.)	Amount of the Tailed monkeys.	1. Hylobates (Gibbons.)	2. Simia (Orangs.)	Amount of the Tailless monkeys.	AMOUNT OF ALL SIMIAE CATARRHINI.
	N	*u*	*m*	*b*	*e*	*r*	*of*	*the*	*Spe*	*cies.*		
ASIA.												
Island of Niphon, ...	.	.	.	.	.	.	.	1	.	.	.	1
Persia and Arabia, ...	1	.	.	.		.	.	1	.	.	.	1
India, including Nepaul, Bhootan, and Assam, from the southern declivity of the Himalaya to the parallel of the Nerbudda River and Calcutta (about 22° north latitude), ...	.	.	4	.	.	.	2	6	3	.	3	9
China and Eastern India, with the exception of Malacca and the Philippine Islands, ...	1	.	2	.	.	.	1	4	1	1	2	6
India, from the parallel of Nerbudda River and Calcutta, ...	.	.	2	.	3	.	1	6	2	.	2	8
Ceylon, ...	.	.	2	.	.	.	1	3	.	.	.	3
Malacca, ...	.	.	1	.	.	.	2	3	3	1	4	7
Sumatra, ...	.	1	3	.	2	1	6	13	4	1	5	18
Borneo, ...	.	.	.	.	.	.	7	7	1	1	2	9
Java, ...	.	.	3	.	.	.	6	9	1	.	1	10
Molucca Islands, with Celebes and Timor	1	.	1	.	1	.	.	3	2		2	5
AFRICA.												
Northern Africa (except Egypt) to the parallel of Timbuctu, or 18° north latitude, ...	.	1	.	.	.	.	.	1	.	.	.	1
Nubia and Darfur, ...	2	.	1	1	3	.	.	7	.	.	.	7
Abyssinia, ...	1	.	1	1	1	.	.	4	.	.	.	4
Western and Central Africa, from the parallel of the River Senegal to Cape Negro, about 16° on each side of the equator; with the adjacent islands, .	3	.	1	6	15	.	.	25	.	1	1	26
Southern Africa, especially south of the Orange River, ...	1	.	.	.	1	.	.	2	.	.	.	2
Island of Mauritius	.	.	.	.	1	.	.	1	.	.	.	1

II. SIMIAE PLATYRRHINI (MONKEYS OF THE NEW WORLD).

	a, SAPAJUS (SAPAJOUS.)					*b*, SAJUINS (SAJOUINS.)						
	1. Mycetes (Howlers.)	2. Ateles (Spider monkeys.)	3. Lagothrix (Gluttonous monkeys.)	4. Cebus (Weepers.)	Amount of the Sapajous.	1. Pithecia (Sakis or fox-tails.)	2. Callithrix (Squirrel monkeys.)	3. Nictipithecus (Night monkeys.)	4. Hapale (Ouistitis.)	5. Midas (Tamarins.)	Amount of the Sajouins.	AMOUNT OF ALL SIMIAE PLATYRRHINI.
CENTRAL AND SOUTH AMERICA.												
Honduras, Panama, the western part of New Granada, to the eastern declivity of the Andes, and the mountainous northern part of Venezuela, . . .	3	2	.	1	6	.	.	.	1	1	2	8
Guayana (English, Dutch, and French),	1	3	.	7	11	4	1	.	2	3	10	21
District of the River System of the Orinoco and Cassiquiare, ...	1	1	1	1	4	3	3	1	1	.	8	12
Ecuador, Peru, and Bolivia, ...	1	2	1	1	5	1	1	.	1	1	4	9
Brazil, ...	5	5	1	6	17	6	8	2	7	6	29	46
Paraguay, and the province of Chaco, with the other countries to the south polar limit of the monkeys	1	.		.	1	1	.	1	.	.	2	3

III. PROSIMIAE (MAKIS.)

	1. Lemur (Lemurs.)	2. Lichanotus (Indris.)	3. Stenops (Lorises.)	4. Otolicnus (Galagoes.)	5. Tarsius (Tarsiers.)	AMOUNT OF ALL PROSIMIAE.
AFRICA.						
Western and Central Africa, ...	.	.	1	2	.	3
Island of Madagascar, adjacent islands, and Mozambique, ...	14	2	.	1	.	17
ASIA.						
Bengal and Coromandel, ...	.	.	2	.	.	2
Ceylon, ...	.	.	1	.	.	1
Siam, ...	.	.	1	.	.	1
Indian Archipelago (Sumatra, Borneo, Java, Celebes, Salayer, and Banca) .	.	.	1	.	1	2

DISTRIBUTION OF THE SINGLE GENERA.

I.—SIMIAE CATARRHINI (MONKEYS OF THE OLD WORLD).

1. TAILED MONKEYS.

1. *Cynocephalus* (baboons). This genus, which has the greatest number of species, is distinguished by its physiognomy, which resembles that of a dog more than that of any other ape. These are generally large, ferocious, and dangerous apes, and attain to a considerable size, being nearly as large as the wolf. They are arranged by Baron Cuvier in two sub-divisions—(1.) Proper baboons; (2.) Mandrills. One of the most common baboons frequently brought to Europe, is the *Cynocephalus porcarius* (chamee). It is not widely distributed—its chief habitat being the mountainous districts throughout the colony of the Cape of Good Hope. *Cynocephalus hamadryas* (dog-faced baboon or derrias) inhabits the countries near the Red Sea; it is common in Arabia, Abyssinia, and on the borders of the Persian Gulf, but is not found in Egypt or Persia. It extends northward from Abyssinia to the mountains of Arkeeko, on the Red Sea (latitude 15° 30′ north); and, according to Salt and Pearce, it is very common in the Highlands of Tigré. The other species, *Cynocephalus anubis* (Nubian baboon), inhabits Northern and especially Central Africa. It extends farther north than any of the other species, being found in the vicinity of the ancient Meroë. The only species inhabiting Asia is the *Cynocephalus niger* (black baboon), which some naturalists class with the genus *macacus*; it is found on Celebes, and it is doubtful whether or not it occurs on the Philippine Islands. The second sub-division, the Mandrills, inhabit only Central Africa. Of these *Cynocephalus mormon* (variegated baboon, or proper mandrill) extends farthest towards the south, but it does not attain the latitude of the Cape colony.

2. *Inuus* (magots). As already remarked, the Barbary ape, a species of this genus, is the only ape whose habitat comes within the limits of Europe. Its chief habitation is on the precipitous sides of the Rock of Gibraltar, which, as stated by the historian of its celebrated siege, is remarkable for the number of apes that breed in inaccessible places about the summit, and appear in large droves, with their young on their backs, on the western face of the hill.

3. *Macacus* (macacos). These are arranged in two sub-divisions—(1.) The long-tailed macacos or cercocebes; (2.) The short-tailed macacos or maimons. To the first, occurring in both continents, belongs the *Macacus cynomolgus* (common macac), which, by several naturalists, as Salomon Müller, in his splendid work on the Dutch East India Islands, is arranged along with the genus *Cercopithecus*. It is the only ape found on the Island of Timor, which, in this archipelago, forms the eastern limit of apes. Dr Horsfield states that this is the most common species of monkey in the forests of Java; it is very generally domesticated, and kept in the stable along with the horses, in the same manner as goats are in England, under the impression that the smell of them is grateful to these animals. Of the remainder, the *Macacus montanus* (mountain macac), is peculiar to Africa, its chief habitat being on the elevated mountain chain of Abyssinia, in the provinces of Hadramaut, Samen, and Gojam. The others inhabit chiefly India and Ceylon; and *Macacus aureus* (tawny macac) occurs in Pegu, Java, and Sumatra. *Macacus radiatus* (toque, bonnet monkey, *bonnet chinois*) is a native of the Malabar coast, from Gujerat to Ceylon. No monkey affords greater amusement in the menageries than the bonnet chinois; and the imperturbable gravity with which it accompanies all its actions is truly diverting. The second sub-division, short-tailed monkeys, or maimons, are peculiar to Asia, inhabiting Hindustan, Ceylon, Java, and Sumatra.

4. *Colobus* (thumbless apes). This genus, which contains but few species, and properly forms only a subordinate group of the Asiatic genus, *Semnopithecus* (solemn apes), is limited to Africa, and occurs principally in the tropical countries of the western coast, where *Colobus comosus* or *polycomus* (royal thumbless ape or full-bottomed monkey) is known to the Negroes of Sierra Leone and Guinea by the name of the king of the monkeys, apparently from the beauty of its coat and its singular head of hair, which resembles a large periwig or a diadem, according to the views of the observers. *Colobus Rüppellii* (mantled thumbless ape) occurs only in the low grounds of the provinces of Gojam, Kulla, and Damot. It is known to the natives by the name of guereza. *Colobus rufo niger* is said to inhabit the district of Algoa Bay, in South Africa; but it is probable that this name has been mistaken for Delagoa Bay, as the former place has long been the residence of an enterprising British colony, to whom, had it existed then, it must have been known; but they, in specifying the natural productions of the district, make no mention of its occurrence.

5. *Cercopithecus* (guenons) is one of the genera which contains the greatest number of species. The individuals vary considerably in size and colour. They herd in troops, and make great havoc among the gardens and cultivated fields. By far the greater number of cercopithees with which we are acquainted come from the western coasts of Africa, where, we are assured by different travellers, they swarm in countless multitudes. In the same district of Africa, as well as in Abyssinia, occur the *Cercopithecus aethiops* (collared mangabey guenon), and *Cercopithecus pyrrhonotus* (Ehrenberg's guenon), *Cercopithecus griseo-viridis* (grivet guenon) is also found, according to Cailliaud, in the forests of Nubia. *Cercopithecus erythropygus, or pygerythraeus* (vervet or red-breasted guenon), inhabits the southern part of Africa. It is the only *cercopithecus*, or, indeed, with the exception of the *Cynocephalus porcarius* (chamee), the only monkey found to the south of the River Gariep. The woods throughout the colony of the Cape of Good Hope, especially in the vicinity of the sea, from Cape Town to Algoa Bay, and thence through the whole extent of Caffreland, abound with this species. *Cercopithecus fuliginosus* (white eyelid monkey), according to Pompper, inhabits the Island of Madagascar. In making this statement, however, he must have been misled by Buffon, who says that it belongs to that island; but F. Cuvier has clearly ascertained that its proper habitat is in Western Africa. The few Asiatic guenons which, for the greater part, inhabit the Continent of India, are, *Cercopithecus carbonarius* (black-faced monkey), *Cercopithecus auratus* (golden guenon), *Cercopithecus talapoin* (talapoin monkey), and *Cercopithecus atys* (*atys*). Only one species, *Cercopithecus faunus* or *cynosurus* (Malbrook guenon) is common to both continents. It occurs in the forests of Bengal and on the coast of Guinea.

6. *Presbytis* (tailed gibbons). The only species of this genus, namely, the capped-monkey, is an inhabitant of the Island of Sumatra.

7. *Semnopithecus* (solemn apes). These are distinguished by a very long tail and a slender, elongated body. They are remarkable for mildness of disposition, great intelligence, and a slowness in their movements—quite the opposite of the vivacity and petulance of the guenons. In India, where they occur in great numbers, they are treated by the natives with a kind of religious veneration. *Semnopithecus nasicus and recurvus.* These two species form, according to Geoffroy and other naturalists, a distinct genus—that of *nasalis.* So also Illigër distinguishes *Semnopithecus nemeus* (Douc or Cochin-China monkey) as a separate genus, that of *lasiopyga*. The former are peculiar to Asia and extend from China to Gujerat, over all India, Ceylon, and the South-eastern Archipelago. Harcourt's discovery of this monkey in Madagascar still wants confirmation. The principal species are: *Semnopithecus nasicus* or *larvatus* (proboscis monkey or kahau), which is distinguished from every other mammiferous animal by the form of its nose, which is from four to five inches in length, narrow at the extremity, and having a furrow in the middle, apparently dividing it into two lobes. It is the only ape of the genus *macacus* which occurs in China; and it extends thence over Cochin-China, the Malay Peninsula, and Borneo, where its flesh is much prized by the natives. *Semnopithecus entellus* (hoonuman), often misspelled houlman. It is highly venerated by the Hindus. Though an inhabitant of the hot plains of India, it ascends the Himalayan Mountains wherever it can find wood. It occurs in Nepaul, on the elevated plains of Bhootan and in Assam, and even in Amboa and Bengal. The celebrated banyan tree, called cubbeerbur, on the banks of the Nerbudda River, is the residence of a numerous colony of hoonumans. *Semnopithecus nemeus*, (Douc or Cochin-China monkey) is one of the most beautiful of its tribe; its chief habitat is in Cochin-China. The remaining species occur chiefly in the great Sunda Islands.

2. TAILLESS MONKEYS.

1. *Hylobates* (gibbons, or long-armed apes) inhabit only the most secluded parts of India and the Eastern Archipelago. *Hylobates syndactylus* (sindactylus gibbon or siamang). It is also called ungka by the Malays of Singapore. This is the largest of the genus. It is slow in its movements—dull and stupid. In the forests of Sumatra, where they are very common, it is said that these gibbons assemble in large companies, and are conducted by a chief. *Hylobates hoolock*, *concolor* or *Rafflesii* (hoolock) is an inhabitant of Sumatra and the territory of Assam; it is also met with on the Garrow Hills, in latitude 25° to 28° north; all the others belong to Malacca and the Island of Sumatra.

2. *Simiae* (orangs). The Asiatic orang-outang is found occasionally in the flat woodlands in the south and west coasts of Borneo, although never to any great extent. It has entirely disappeared from the vicinity of Benjar Masseen, having been driven from this thickly populated part of the island. On Sumatra, it inhabits the low woodlands on the east coast, especially towards the north, and extends thence over Malacca and the southern part of Assam. It is of solitary habits, living generally alone. The habitat of the African *orang-outang*, in so far as ascertained, extends from the banks of the Gambia to the southern boundary of Benguela, comprehending the whole coast of the Gulf of Guinea, and embracing an extent of 13° of latitude on each side of the equator. It occurs chiefly in the interior of the country, and it appears more frequently on hills of moderate elevation than on plains.

II.—SIMIAE PLATYRRHINI (MONKEYS OF THE NEW WORLD).

In many respects these monkeys differ in a remarkable manner from those of the Old World. The most striking external difference consists in the smaller size and less ferocious manners of the greater number, the prehensile tail of many; and in all the naked callosities and the want of cheek-pouches. Buffon first proposed the division of this family into two sub-tribes—the *sapajous* and the *saguins*, according as their tails are or are not prehensile.

1. SAPAJUS (SAPAJOUS).

Mycetes (howlers). Animals of this species derive their name from the remarkable howling sound they emit, which resembles the grunting of a herd of swine. They are, in general, of a large size, and have the widest circle of distribution of the entire genus, extending farthest to the north as well as to the south. The species which stretches farthest to the north in Central America is, *Mycetes seniculus* (mono colorado, royal or red howler), the figure of which is given among the typical representations. *Mycetes ursinus* (ursine howler, or araguato). This, which differs little from the preceding species, is an inhabitant of the northern part of South America and Brazil. *Mycetes stramineus* (straw-coloured howler, arabata), an inhabitant of Peru, is one of those which rarely occur on the east side of the Andes. *Mycetes niger* (caray or black howler), which extends to the southern districts of Paraguay, is one of the most corpulent of monkeys, the flesh of which is preferred by the Portuguese in Brazil to that of ducks.

2. *Ateles* (spider monkeys). In their general contour they resemble the guenons of the Old World. They are generally mild, timid, melancholy, and slow in their movements. They inhabit chiefly the countries of Brazil and Guayana, and do not extend southward farther than to the parallel of Rio de Janeiro. *A. hypoxanthus* (Mikiri) often erroneously spelled Miriki, are very plentiful in the maritime provinces of Brazil, from St Paul to Bahia, and extend only between the latitudes of 13° to 23° south.

3. *Lagothrix* (gluttonous monkey). The genus *lagothrix* of Cuvier and Geoffroy is called *gastrimargus* by Spix; and this has sometimes led to the error of considering it as two separate genera. Only two species are known, and these inhabit chiefly the tropical countries of the interior of South America; indeed their constitution renders them so dependent on the heat of tropical climates, that a specimen brought on its way to Europe dies from the effects of cold by the time it reaches the Azores.

4. *Cebus* (weepers). The animals comprising this genus are of a mild disposition; they are quick and lively in their movements, and are very readily tamed; they are excellent climbers, and in all their members show a great adaptation for a sylvan life. The name "weeper" is derived from the plaintive cry which they utter. This genus has the greatest number of species of any ape in the New World; but its circle of distribution is more limited than many of the others. It extends southward to about the Tropic of Capricorn. On the west it scarcely reaches to the foot of the Andes, and is not found in the northern part of Venezuela. It is found in the greatest numbers in Guayana, and is frequently brought to Europe.

2. SAGUINS (SAGOUINS).

1. *Pithecia* (sakis or fox-tails). Several of the saguins, from their having long and bushy tails, have been called fox-tailed monkeys. This genus is one of them. One species having the tail smaller than the body, is by Spix separated from the remainder, to form his genus *brachyurus*. The *pithecias* usually reside in the depths of the forest, where they conceal themselves, or sleep during the day. They extend over the countries from the banks of the Orinoco to Paraguay and the province of Chaco. *Pithecia satanas* (black fox-tail). The limits of distribution of this species is distinguished on the map, and a representation of it is given among the types.

2. *Callithrix* (squirrel monkeys). This genus is of a small size, and prettily coloured. Its chief habitat is on the banks of the Orinoco.

3. *Nictipithecus* (night monkeys). These differ from the other saguins only by their large nocturnal eyes, and by having their ears partly concealed under the hair. They have a strong general resemblance to the loris of the Old World. They inhabit the countries of Guayana and Brazil.

4. *Hapale* (ouistitis) }
5. *Midas* (tamarins) } marmousets. These are diminutive animals, of an agreeable form, having a tail longer than the body; their fur is generally long, bushy, and very soft to the touch, and of brilliant and beautiful colours. Their chief habitat is Brazil; but they extend also to Guayana and the northern districts of South America to the banks of the Rio Magdalena. Of the genus midas, the most remarkable is *Midas Leonina* (leonine tamarin or leonito). It is a very rare species, and inhabits the plains of Mocoa, bordering the eastern slope of the Cordilleras and the fertile banks of the rivers Putumayo and Caqueta, and never ascends to the more temperate districts. It is only from seven to eight inches in length, and is extremely elegant. It is playful in its disposition, but is easily angered. Humboldt, who discovered this species, observes, that when enraged or tormented, it bristles up the hair of the neck, so as to increase its resemblance to a miniature lion; its cry resembles the chirrup of some small bird.

III.—PROSIMIAE (MAKIS).

The makis, according to Linnæus, comprise all those quadrumanous animals whose incisors are more or less than four in number, or whose teeth are directed differently from those of the apes or monkeys. They vary very much in size, and are generally very small; most of the species are not larger than a rat or mouse, with the exception of those of the genus *lichanotus* (indris), which attain to the size of the baboon. The two first genera *lemurs* (lemurs) and *lichanotus* (indris) inhabit only Madagascar, with the adjacent islands, and Mozambique. In the same district there occurs, of the remaining genus, *otolicnus* (galagoes), and on the continent of Africa, *stenops* (lorises). In Asia, there occur only the small, harmless animals, the *lorises* and *tarsiers*, which, on account of their mysterious conduct—their nocturnal prowling and their extraordinary large, sparkling eyes—have excited in the imaginations of the natives the most superstitious feelings. They ascribe to them the most singular peculiarities, in consequence of which they are regarded by young and old with the greatest mistrust. *Tarsius spectrum* (podge tarsier) is found only in the islands of Celebes, Borneo, Salayer, and Banca; but the lorises occur also in the Islands of Sumatra and Ceylon, as well as on the Continent, in Siam and Bengal.

PERPENDICULAR DISTRIBUTION.

In the Zoological division of our Atlas, we have attempted to show, by diagrams, the perpendicular distribution of animals with reference to the snow line, the limits of trees, and other important meteorological and botanical circumstances, which have so great an influence on the animal world. The scale of these diagrams is made to correspond with those on the Map of Botanical Geography (No. 1), in order to show at once the striking connection that subsists between the two kingdoms; but, on the present map, want of space has limited these diagrams to the first of the four orders of animals represented, namely, that of the monkeys, for which, however, the greatest number of observations exist. On the second map of this division, containing the *Carnivora*, will be found, interesting representations of the different animals which inhabit mountainous regions.

Among the monkeys of the Old World, the *Semnopithecus entellus* (hoonumans) ascend to the greatest height. They are found in Nepaul and Bhootan in great numbers, and ascend the Himalayan Mountains wherever they can find wood—that is, to a height of above thirteen thousand feet. In Africa, *Macacus montanus* (mountain macac) ascends the Abyssinian Highlands, to a height of eight thousand feet. In the New World, *Mycetus rufimanus* (beelzebul) ascends the eastern declivity of the Andes to a height of above eleven thousand feet.

SECOND SECTION.

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF THE MARSUPIALIA (*POUCHED ANIMALS*) IN THE WHOLE WORLD GENERALLY, AND IN AUSTRALIA, &c., SPECIALLY.

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

In the construction of this section of our map we have been principally indebted to the ample and admirably arranged materials furnished by Mr Waterhouse, in his recent publication on Marsupial quadrupeds;[1] and we have followed the classification therein adopted, which is based on that of Professor Owen, communicated to the Zoological Society in 1839, with the exception of the two last named genera: *echidna* and *ornithorynchus*, forming the family of *Monotremata*, for which we have substituted the genus *dendrolagus*, recently discovered by Salomon Müller, in New Guinea. In form, the dendrolagus resembles the kangaroo, but in its power of climbing it is more nearly allied to the phalanger.

Of all the orders of Mammalia, there is none the knowledge of which is more rapidly and steadily extending, than that of the Marsupialia. Australia is the great central locality of these animals; and the more this singular country is explored, the more ample does our list of its genera and species become. Mr Waterhouse reckons, in all, 105 species—nearly twice the number named in many recent treatises; and since the time of his publication (1841) 18 new species have been discovered, and described in the proceedings of the Zoological Society of London. The greater part of these are kangaroos, ten of which have been discovered in Western Australia, others at Port Essington on the north, and on Barrow Island on the north west coast. We may, therefore, assume the number of species known at the present time to be 123 species, forming one-twelfth of all Mammalia.

The classification referred to is as follows:—

	Families.	Genera.	No. of Species.
MARSUPIALIA OF THE NEW WORLD, = 21 SPECIES.	*Didelphidae*	1. Didelphys (Opossums)	21
MARSUPIALIA OF THE OLD WORLD, = 87 SPECIES.	*Dasyuridae*	2. Thylacinus	1
		3. Dasyurus	5
		4. Phascogale	7
	Myrmecobiidae	5. Myrmecobius	2
	Peramelidae	6. Perameles	7
		7. Chaeropus	1
	Macropopidae	8. Macropus (Kangaroos)	40
		9. Hypsiprymnus	10
	Phalangistidae	10. Phalangista (Phalanger)	15
		11. Petaurus	10
		12. Phascolarctus (Koala)	1
	Phascolomidae	13. Phascolomys (Wombat)	1
	Dendrolagidae	14. Dendrolagus	2

The Marsupialia are distributed over the countries within the torrid and temperate zones of Australia, the Asiatic Archipelago and America; but in Africa, and on the Continent of Asia, no pouched animal is known to exist. In America they extend farthest towards the north, reaching to the southern borders of Canada, or to about latitude 42° north. In Van Diemen's Land they attain their southernmost limits, namely, about latitude 43° 30′ south. In the Asiatic Archipelago they are spread over the islands of Celebes and Java; in which last, however, only one species has hitherto been observed, namely, *Macropus Brunii* (filander kangaroo), discovered by Le Brun, in the vicinity of Batavia.

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[1] Naturalist's Library, vol. xi.—Marsupialia, or pouched animals. By G. R. Waterhouse, Esq., Curator of the Zoological Society of London.

The squirrel-like petaurus (*Pet. sciureus*) extends, according to Cuvier (1827), eastward to Norfolk Island; but as it is not mentioned by any more recent authority, we have marked it doubtful on the map.

DIVISION AND INTENSITY OF THE SPECIES.

The countries embracing the colony of New South Wales, and the south-eastern districts of Australia, contain the greatest number of pouched animals, since there, ten out of the thirteen genera belonging to the Old World are found, and these comprise, in all, thirty-nine species. In the countries just mentioned, and in the Island of Van Diemen's Land, only the largest class of the marsupial animals occur. In order more clearly to exhibit the species belonging to each genus, we have compiled the following:—

TABLE SHOWING THE DIVISION OF *MARSUPIALIA* (*POUCHED ANIMALS*) OVER THE GLOBE, ACCORDING TO THE NUMBER OF THEIR SPECIES.

REGIONS AND COUNTRIES (From North to South.)	DIDELPHIDAE.	DASYURIDAE.			MYRMECOBIIDAE.	PERAMELIDAE.		MACROPODIDAE.		PHALANGISTIDAE.			PHASCOLOMIDAE.	DENDROLAGIDAE.	AMOUNT OF ALL MARSUPIALIA
	Didelphys (Opossum.)	Thylacinus.	Dasyurus.	Phascogale.	Myrmecobius.	Perameles.	Chaeropus.	Macropus (Kangaroo.)	Hypsiprymnus.	Phalangista (Phalanger.)	Petaurus.	Phascolarctus (Koala.)	Phascolomys (Wombat.)	Dendrolagus.	
	N	*u*	*m*	*b*	*e*	*r*	*of*	*S*	*p*	*e*	*c*	*i*	*e*	*s.*	
OLD WORLD.															
Asiatic Archipelago, comprising the Islands of Java, Celebes, Timor, Ceram, Amboina, Banda, and Waigiou,	.	.	.	.	.	.		1	.	4	.	.	.	.	5
New Guinea and New Ireland,		.	.	1	.	1	.	1		2		.	.	2	7
North and north-east coast of Australia, from Port Essington to Barrow Island, .	.	.	.	.	.	.	.	5	.	.	.	.	.	.	5
West Australia, from Shark's Bay to King George's Sound,	.	.	.	2	2	3	.	12	6	.	.	.	.	.	25
New South Wales, and generally south-east Australia, from 30° south latitude to Spencer Gulf, ...	.	.	2	3	.	2	1	15	5	3	6	1	1	.	39
Van Diemen's Land, and the Islands in Bass' Strait, . .	.	1	4	1	.	2	.	5	.	2	Norfolk Island 1 Species.	.	1	.	17
NEW WORLD.															
North and Central America, and the Antilles, ...	4	.	.	.	.	.	.	.	.	.	.	.	.	.	4
Guayana, ...	6	.	.	.	.	.	.	.	.	.	.	.	.	.	6
Brazil, ...	9	.	.	.	.	.	.	.	.	.	.	.	.	.	9
The northern and western parts of South America, comprising Venezuela, New Granada, Ecuador, Peru, and Bolivia, ...	2	.	.	.	.	.	.	.	.	.	.	.	.	.	2
The southern parts of South America, from the Tropic of Capricorn to 36° south latitude, comprising Chile, La Plata, Paraguay, and Uruguay, ...	6	.	.	.	.	.	.	.	.	.	.	.	.	.	6

DISTRIBUTION OF THE SINGLE FAMILIES.

1. *Didelphidae.* This is the only family found in the New World, and, as shown on the map, the district over which it is distributed is more extensive than that of any family of the Old World. *Didelphys virginiana* (Virginian opossum) extends from the southern limits of Canada, through the United States and Mexico to the Antilles, where it is called manitu. According to Pennant, it is also found in Peru and Brazil. This is the largest species of the family, and attains to about the size of a cat. The other species are generally so small that they might, by a common observer, be mistaken for rats or mice, were it not for their elongated and pointed muzzle. *Didelphys dorsigera*, found in Surinam, derives its name from the habit of carrying its young on its back. In place of the usual pouch, the females have a fold in the skin of the belly, which may be regarded as a rudimentary pouch. When old enough to leave the teats, the young are carried on the back of the parent, where they maintain themselves by entwining their prehensile tails round that of the mother. On the western side of the Andes, marsupial animals appear to be very uncommon, since only one species, *Didelphys elegans* (elegant opossum) has yet been observed; it was discovered by Mr Darwin, in the neighbourhood of Valparaiso, where he says they "frequent thickets growing on the rocky hills," and are exceedingly numerous. One species lives in the water, and appears to resemble the otter in its habits. It constitutes the genus *Chironectes* of Illiger; but Mr Waterhouse says it should be regarded as a sub-genus of the *Didelphys.* This species is found in all the smaller streams of Brazil, and extends from the southern border of that empire to the shores of the Gulf of Honduras.

2. *Dasyuridae.* As shown by the lines on the map, these animals are limited to the countries of New South Wales and Van Diemen's Land, with the exception of one single species, which is found in New Guinea. They do not live upon trees, like most of the true oppossums, but hide themselves in holes or in crevices of the rocks during the day, and at night prowl about like weasels in search of their prey. The *Thylacinus* inhabits only Van Diemen's Land, "where it is called the tiger-hyæna, and used formerly to be known among the colonists by the names, zebra-oppossum, and zebra-wolf." The most ferocious of all the species is *Dasyurus ursinus* (ursine dasyurus), which is an inhabitant of Van Diemen's Land, and is called by the colonists the native devil. It is a voracious feeder, and is described as the most destructive of all the indigenous quadrupeds. The *Phascogales* are the smallest animals of the family of the Dasyuridae, being commonly about the size of a rat. They occur throughout the colony of New South Wales, and have been found at Adelaide, in South Australia. Salomon Müller discovered a species of this genus in New Guinea. which was distinguished from all the others by the blackness of its fur.

3. *Myrmecobiidae.* This beautiful and interesting little animal, which is about the size of a squirrel, was discovered by Lieutenant Dale, in the Swan River settlement, about ninety miles to the south-east of the Swan River.

4. *Peramelidae.* The district of distribution of these animals extends from New Guinea to Van Diemen's Land. They feed on insects and vegetable substances. That discovered by Major Mitchell, at the River Murray, and described by Ogilby, genus *Chaeropus*, differs from the *Perameles* in the absence of a tail, and in the form of its fore feet, which strongly resemble those of the genus sus (swine).

5. *Macropopidae* (the Kangaroos). These animals, as Mr Waterhouse observes, "are remarkable for the flexibility and lightness of the anterior parts of the body, the smallness of the anterior members, and the great size of the posterior extremities, and of the tail." The young, when first produced, are imperfect in their development, and not larger than a mouse. By some unknown means, they are conveyed to the external pouch, where they remain firmly attached to the nipple till their development is perfected, and till they have increased greatly in size. The kangaroos have the greatest number of species of any family of the order, having not fewer than forty, or about one-third of all the species of Marsupialia. They are also the most widely distributed of any family in the Old World, since they occur in all hitherto discovered parts of Australia and New Guinea, and according to Le Brun are found also in the Island of Java. One of the most beautiful animals of the genus macropus, the proper kangaroos, is *Macropus fasciatus* (the banded kangaroo). It is about the size of a rabbit. Its habitat is on the islands in Shark's Bay, on the west coast of Australia, and it appears not to occur on the mainland.

6. *Phalangistidae.* All the phalangers are nocturnal in their habits; they live in trees, and are expert climbers. Of all the Marsupialia which inhabit the islands of the Asiatic Archipelago and New Guinea, these are the most numerous and common, and they are the only ones which inhabit the island of Celebes. The beautifully marked species *Phalangista maculata* (the spotted phalanger) is distributed, as will be seen by the limits on the map, over the islands of New Guinea, Ceram, Amboina, Banda, and Timor. This species is also represented among the typical figures. The genus *Petaurus* occurs only in New South Wales, at least, as already mentioned, it is uncertain whether it is also found in Norfolk Island. The genus *Phascolarctus*, which possesses only the single species *Phascolarctus fuscus* (the koala), is likewise limited to New South Wales.

7. *Phascolomidae.* This family, which includes the wombat (Phascolomys wombat), possesses only one species; it is found in the colony of New South Wales, South Australia, and Van Diemen's Land, as well as in some of the islands of Bass' Strait.

8. *Dendrolagidae.* The only known species of this family, as already mentioned, was discovered by Salomon Müller in the western district of New Guinea.

THIRD SECTION.

DIVISION AND DISTRIBUTION OF THE *EDENTATA* (*TOOTHLESS ANIMALS*).

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

The Edentata, that strange assemblage of animals which, on account of their defective system of teeth, have all been classed in one order, contain only twenty-eight species, forming one-fifty-fourth of all Mammalia. These form the following eight genera:—

NEW WORLD.	No. of Species.	OLD WORLD.	No. of Species.
1. Bradypus, Bradypus tridactylus or acheus (ayei) . . . sloths,	2	5. Orycteropus (African ant-eater) . .	1
Bradypus didactylus or choloepus (unau) . "	2	6. Manis (pangolin)	4
2. Dasypus (armadill	11	7 Echidna, tachyglossus (porcupine ant-eater)	2
3. Clamyphorus (pichie) . . .	1	8. Ornithorynchus	1
4. Myrmecophaga (American ant-eater) . .	4		

The Edentata inhabit chiefly the countries of South America, where, as the preceding table shows, there are nearly three times as many species as are found in Asia, Africa, and Australia, together. They extend farthest towards the north in the Old World, namely, to about 27° 30′ north latitude, in Nepaul. In the Southern Hemisphere, they extend about 16 degrees farther from the equator, in the New as well as in the Old World. In the former they are found in the plains of Patagonia, and in the latter at the southern point of Van Diemen's Land.

DIVISION AND INTENSITY OF THE SPECIES.

As already observed, the New World is the proper country of the Edentata, and here they are not, as in the case of the monkeys and pouched animals, limited, in general, to tropical America, since they extend to the plains of Patagonia, where the annual mean temperature corresponds with that of the south of England. In the whole of South America, from the Tropic of Cancer southwards, especially in the great plains of the pampas the Edentata are the most numerous of all Mammalia, and are the characteristic animals of those countries; the *Clamyphorus*, which is the smallest of all the Edentata, is characteristic of this region; in consequence of which the intensity of the species is pretty equally distributed over the countries from Guayana to La Plata. In Asia, Africa, and Australia the occurrence of the Edentata is only occasional; wide spaces separate the genera which are poor in species; yet it contains one of the most singular of all Mammalia namely, the ornithorynchus.

TABLE SHOWING THE DIVISION OF *EDENTATA* (*TOOTHLESS ANIMALS*) OVER THE GLOBE, ACCORDING TO THE NUMBER OF THEIR SPECIES.

REGIONS & COUNTRIES	Bradypus (Sloths.)	Dasypus (Armadillos.)	Clamyphorus (Pichiciago)	Myrmecophaga (Am. Ant eater	AMOUNT OF ALL SPECIES.
	N u m	*b e r o f*	*S p e*	*c i e s.*	
NEW WORLD.					
Central-America, from the southern limits of Mexico; New Granada, Venezuela and Guayana, . .	3	7		2	12
Brazil to the Tropic of Capricorn, ...	3	8	.	3	14
From the Tropic of Capricorn to the Patagonian Plains, about 43° s. lat.; including Paraguay, La Plata, Chile, and Patagonia . . .	.	9	1	2	12
OLD WORLD.	Orycteropus (African Ant-Eater.)	Manis (Pangolins.)	Echidna s. Tachyglossus (Porcupine Ant-eater)	Ornithorynchus.	AMOUNT OF ALL SPECIES.
Asia, ...	.	2	.	.	2
Africa, ...	1	2	.	.	3
Australia . . .	.	.	2	1	3

NEW WORLD.

1. *Bradypus* (sloths). The district of these animals extends from the southern limits of Mexico to Rio de Janiero, including Central America, New Granada, Venezuela, Ecuador, Guayana, and Brazil, to the eastern declivity of the Andes, where the primitive forests, to a height of about 3,000 feet, in the regions of palms and scitamineæ, are inhabited by these slow and unwieldy animals. *Bradypus tridactylus s. acheus* (three-toed common sloth or ayei) has the widest district of any of the species, since it extends from Honduras to Brazil, in about latitude 17° 30′ south; whilst *Bradypus didactylus s. choloepus* (unau) the larger species, is found only in Guayana.

2. *Dasypus* (armadillos). Like the sloths, the armadillos are peculiar to the New World, and no similar animals are found in any other part of the globe. They extend from the banks of the Orinoco, through the whole of South America, and form the southernmost limits of American Edentata; they live in the plains as well as on the table-lands, and occupy the lower regions of the Andes to the same height as the sloths. The number of species increases from north to south, and attains its maximum in the plains and pampas of Paraguay and La Plata. *Dasypus tolypentes* (one-banded armadillo) occurs only in Chile, La Plata, and Paraguay. It has the power of rolling itself like a ball, and has hence been considered by some naturalists as a separate genus. *Dasypus peba* (tatouhou, or nine-banded armadillo). This species, of which we have given a representation, is distributed over the countries of South America, from Guayana to Paraguay, in the former of which it is very common. It is never found in the woods, but frequents the open cultivated plains; and is much hunted by the inhabitants on account of its flesh, which, when roasted in the shell, is said to be extremely delicate. This is one of the smallest of the armadillos. The largest *Dasypus giganteus s. gigas* (giant, or great armadillo) is more than three feet long. Its district extends from Guayana, Brazil, and the northern part of Paraguay to Assumption. As the previously mentioned species never inhabits the woods, so, on the contrary, this is never found in the open country, but keeps in the close vicinity of the great forests.

The remaining species almost all inhabit the same district, which extends over Guayana, Brazil, and Paraguay. *Dasypus vardadeiro* (vardadeiro armadillo) is found only in Brazil, and *Dasypus gymnurus* only in Paraguay.

3. *Clamyphorus* (pichiciago). This extraordinary little creature, scarcely six inches in length, is formed on a plan which combines the utmost strength and solidity. It is a native of Chile and La Plata, but is so rare that it is regarded by the natives as a curiosity.

4. *Myrmecophaga* (American ant-eaters). These animals do not extend so far towards the south as the armadillos, since they are not found beyond Buenos Ayres. *Myrmecophaga jubata* (the great ant-eater or ant-bear) is characterized by the total absence of teeth, by a narrow head, and an extremely slender elongated snout. This is the largest of all toothless animals. It feeds almost entirely on insects, especially, as its name implies, on ants. *Myrmecophaga didactyla* (the little ant-eater). This species which, as shown in the drawing, differs so completely in size and form from the former one, is found only in the forests of Guaiana and Brazil.

OLD WORLD.

5. *Orycteropus* (African ant-eaters). This genus has only one species—*Orycteropus capensis* (Aardvark), which inhabits the countries of the Cape Colony, and extends northwards to Congo. It is essentially burrowing in its habits. The burrows formed by these animals are dangerous to waggons travelling over the country; as in districts where they are numerous, and where also vast numbers of ant-hills cover the plain, horses and cattle, breaking through the surface of the ground, suddenly stumble and fall.

6. *Manis* (pangolins, or scaly ant-eaters). These are common to Asia and Africa; the species represented in the types—*Manis longicaudata* (long-tailed pangolin)—is the best known species, and inhabits Senegal and Guinea. Of the two species of the Edentata found in Asia, both belonging to the genus manis, the one, *Manis brachyura* (short-tailed pangolin), occurs in Bengal, Bahar, Nepaul, the southern districts of China, and the Island of Formosa. It is very common in the Deccan in India.

7. *Echidna s. tachyglossus* (porcupine ant-eater, the hedgehog of the colonists of Sydney). This species is also characterized by the total absence of teeth. It is a native of Australia, and is most common in New South Wales. It occurs also in the islands in Bass' Strait, and in Van Diemen's Land.

8. *Ornithorynchus* (water mole of the colonists—mallangong and tambreet of the natives). This is the most singular animal belonging to the class Mammalia, and is of peculiar interest, especially to the physiologist. From its duck-like beak and webbed feet, it appears externally to partake in some degree of the nature of a bird, and its first discovery created the most lively astonishment among naturalists. Hitherto it has only been found in the south-eastern parts of Australia, namely in the rivers Yas Murrumbidgee, Fish, Newcastle, Campbell, and Macquarie.

FOURTH SECTION.

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF THE PACHYDERMATA (*THICK-SKINNED ANIMALS*).

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

The order of the Pachydermata, or thick-skinned animals, so called from their tough, puckered, and almost impenetrable hides, contain, in all, nine genera, and thirty-nine species, exclusive of the feral or wild horse, and all domesticated Pachyderms, as the horse, the ass, the mule, and the swine, which are here entirely left out of view. These thirty-nine species form one-thirty-eighth of all Mammalia, and are divided among the genera in the following order:—

1. Elephas (Elephants), ...	2 species.
2. Hippopotamus, ...	1 ,,
3. Rhinoceros, ...	7 ,,
4. Hyrax (Damans), ...	3 ,,
5. Sus (Swine), ...	9 ,,
6. Phascochoerus (Wart Hogs), . . .	3 ,,
7. Dicotyles (Peccaries), ...	2 ,,
8. Tapirus (Tapirs), ...	3 ,,
9. Equus (Horses), ...	9 ,,

The Pachyderms, as well as the three other orders of animals represented on this map, are found chiefly in the countries of the torrid zone; but they extend farther towards the poles than the others, especially in the Northern Hemisphere of the Old World, where they attain to latitude 57° 30′ north. In the Southern Hemisphere they do not attain the same latitude, since the common American tapir forms the southernmost member of the order, in about latitude 40° south. In North America no thick-skinned animal is found, unless the wild horse (of which large herds are found in Western Mexico, California, and the river districts of the Columbia) be considered as indigenous to the New World. The Continent of Australia contains no animal whatever belonging to this order. Of the four orders represented on this map, the Pachyderms alone are found in Europe and Central Asia, to the north of the Himalayan Mountains.

These animals generally frequent retired forests and thick jungles, preferring such as are watered by some noble stream, in which they can bathe and wallow during the hotter parts of the day.

DIVISION AND INTENSITY OF THE SPECIES.

A comparison of the typical animals of this order, represented on the borders of the map, will show at a glance how few in number and how small in size those of the New World are, in comparison with those of the Old World. The abundance of Pachyderms in the Old World seems to compensate for the paucity of the pouched and toothless animals; thus tending to restore the balance of the fauna of the different continents of the globe. The greatest number of species of Pachyderms, as shown, by the shading on the map, occur in Africa, to which country the hyppopotamus, zebra, wart hog, and the greater number of the hyrax, are peculiar.

TABLE SHOWING THE DIVISION OF THE *PACHYDERMATA* (*THICK-SKINNED ANIMALS*) OVER THE GLOBE, ACCORDING TO THE NUMBER OF THEIR SPECIES.

REGIONS.	Elephas (Elephants.)	Hippopotamus.	Rhinoceros.	Hyrax (Damans.)	Sus (Swine)	Phascochoerus (Wart hogs.)	Dicotyles (Peccaries.)	Tapirus (Tapirs)	Equus (Horses.)	AMOUNT OF ALL SPECIES.
OLD WORLD.			NUM	BER	OF	SPE	CIES.			
EUROPE.										
Central and Southern Europe, from about 57° north latitude	.	.	.	.	1	.	.		.	1
ASIA.										
Central Asia, from about 54° to 30° north latitude, or from the Lake of Baikal and the Siberian plains at Omsk, to the southern confines of Thibet, including the whole of Arabia and Iran . . .	.	.	.		1	.	.	.	5	6
Southern Asia, from 30° north latitude, excluding the Malay peninsula, and including Ceylon	1	.	1	.	1	.	.		1	4
Asiatic Archipelago and the Malay peninsula, with the Island of Papua . . .	1	.	2	.	6	.	.	1	.	10
AFRICA.										
Northern Africa, from the southern limits of the Sahara, and the northern declivity of the Abyssinian table-land to 15° north latitude	.	1	.	1	1	.	.	.	.	3
Central and Southern Africa, from the southern limits of the Sahara, with the Island of Madagascar	1	1	4	3	1	3	.	.	3	16
NEW WORLD.										
Central America, from the southern confines of Mexico and South America to the equator	.	.	.	.	.	.	2	2	.	4
South America, from the equator to the pampas of La Plata	.	.	.	.	.	.	2	1	.	3

DISTRIBUTION OF THE SINGLE GENERA.

1. *Elephas* (elephants). These gigantic animals inhabit the tropical forests of Asia and Africa, living in herds, in a state of inoffensive quiet, unless when attacked by some of the larger and stronger animal assailants, or by their powerful and more relentless enemy—man. *Elephas Indicus* (Indian or Asiatic elephant). As its name implies, this animal is a native of the Indian world. Its habitat extends from the southern point of Sumatra, latitude 6° south, through that island, across the peninsula of Malacca, over the southern provinces of China, Yun nan, and Kwang-se, and in all India on both sides of the Ganges, including Ceylon, to the marshy woodlands of Tarai, which are situated between the River Ganges at Hurdwar, and Ram Ganga, along the foot of the Himalaya, to nearly 30° north latitude. It ascends the Himalayan Mountains, in the forest wildernesses of Nepaul, to a height of from five to six thousand feet.—In reference to the occurrence of the Indian elephant in the Asiatic Archipelago, Salomon Müller, who has so thoroughly studied the fauna of these islands, says that Sumatra alone has been known from the earliest times as the habitation of this animal; and that after the most minute research, he could find no trace of it in Borneo. Pigafetta, indeed, states, in his account of the voyage of Magalhaen, that on arriving in the town of Borneo, he found two elephants belonging to the king; but these were probably imported from the continent or from Sumatra, whence young elephants are frequently conveyed to Java, and whence also the royal stables of Pekin have, from time immemorial, been supplied. It is still possible, however, that elephants may be found in the unexplored countries of the northern part of Borneo. Buffon's statement, that the elephant is an inhabitant of Java, is clearly founded on erroneous information.—The native country of *Elephas Africanus* (the African elephant) extends from the northern borders of the Cape Colony to the River Senegal on the west, and to Abyssinia on the east, but in Central Africa it does not appear to extend so far to the north; at least it has not been found in the vicinity of Lake Tchad. In Abyssinia it extends to about latitude 13° north, in the mountains north of Abou Huaze (south of Senaar); and its highest southern latitude is about 31° south, on the southern borders of the table-land, whence, however, it is receding before increasing cultivation.

2. *Hippopotamus.* This genus, containing only one species, *Hippopotamus amphibius* (common hippopotamus), is peculiar to Africa, where, in former times, it was more widely distributed than at present, since it is ascertained that, at the beginning of the seventeenth century, it was captured even in the Nile Delta, where it was first known by the name of the "river horse." Its present habitation extends from the River Gariep and its tributaries to the Upper Nile in Dongola, where it is very common, and where neither the elephant nor rhinoceros are met with. Burckhardt says, that the hippopotamus is occasionally, though rarely, seen as far north as the Cataracts of the Nile at Es Souan, but in the district of Abyssinia, watered by the Tacazze, a tributary of the Nile, it is very abundant, as well as in the River Niger. It occurs in the River Senegal, and was observed by Clapperton in the Lake Muggabey, Bornou, and in Lake Tchad and its tributary streams. According to Mr Bidwell (Proceed. Zool. Soc. London, 1839), it is not found in the Sierra Leone River, but is very abundant in the Scarcies, about fifty miles farther north.

3. *Rhinoceros.* This genus, which, like the elephant, is common to Asia and Africa, contains three Asiatic and four African species. It is confined to nearly the same limits as the elephant. In Africa, indeed, the limits of the two entirely coincide; and in Asia, the only difference is, that the habitat of the rhinoceros extends a little farther to the north in China, and includes the Island of Java. *Rhinoceros Indicus s. unicornis* (Indian rhinoceros) is a native of the whole Indian continent. It is most abundant in Bengal, and extends to the Chinese province of Sze-chuan. Of the two other species, one, *Rhinoceros Sumatranus,* inhabits Sumatra; and the other, *Rhinoceros Javanus* (Javanese one-horned rhinoceros or warak), the Island of Java. Salomon Müller has not been able to ascertain whether or not the rhinoceros occurs in Borneo; he could only learn that one of the natives had, in his youth, seen a specimen about the size of a buffalo; but he made many interesting observations on their distribution in the Islands of Java and Sumatra. In consequence of their great strength, and their indifference to the changes of climate, these animals wander from the sea-shore to the summit of the bell-shaped volcanoes of Java, where their foot-prints, furrowed to a depth of several feet, are often observed to a height of nearly eight thousand feet, in the rough and naked vicinity of the craters.—Of the African rhinoceros, which consists of three species with two horns, and one species with one horn, the common, or two-horned African rhinoceros, has the largest district of distribution, occupying the same extent of country as the African elephant, whilst the three other species are more confined to the interior. *Rhinoceros simus* (white or blunt-nosed rhinoceros) occurs in great abundance near Litakou, latitude 26° south. *Rhinoceros keitloa* (Keitloa), the African one-horned rhinoceros, is found, according to Burckhardt, in the territory above Senaar; and Bruce says that it occurs near Cape Guardafui; and it may be added, on the authority of Mr Freeman, that it is not uncommon in Makooa, north of the Mozambique Channel

4. *Hyrax* (damans). Receding, in its pigmy size, from the great bulk of the proboscidean animals, this, the smallest of the thick-skinned Mammalia, approaches nearest in form to the Glires or Rodentia, looking like a diminutive hare. Its district is not extensive, having hitherto only been observed in Southern Africa, in the Nile countries, and in Syria. The most common species in Southern Africa is *Hyrax capensis* (Cape hyrax, or dassie of the colonists). It is abundant on the sides of Table Mountain, where it inhabits the crevices of rocks. Another species (*Hyrax arboreus*) was observed by Mr Smith in the interior of the country. *Hyrax Syriacus* (Syrian hyrax—askoko of the natives of Ambara—Israel's sheep of the Arabs) extends from the Abyssinian province of Amhara to the mountains of Horeb and Sinai, and is very abundant on Mount Libanus.

5. *Sus* (swine). These have the largest district of distribution of all the Pachyderms, and assume, in different countries, the greatest variety of forms; for the *phascochoerus* in Africa and the *peccaries* in America are only varieties of the swine. The true swine are distributed in three groups, namely, the European-Asiatic, the Indian, and the South African groups. The European-Asiatic group consists of the *Sus scropha* (the wild boar), which extends from the Atlantic coasts of France and Morocco to the shores of Japan and the Chinese Sea, on the one side, from the Gulf of Tonquin to Lake Baikal in Siberia; and on the other, from the borders of the Sahara to the Lithuanian woodlands (which, in the heart of European cultivation, still resemble primitive forests). Thence the wild boar sometimes strays to the Baltic provinces of Russia, where, in Courland, it is occasionally followed by the daring huntsman; but it is unknown in the European countries bordering on the western parts of the Mediterranean; therefore, the statement which is occasionally met with in geographical books, that "it is followed in a wild state by impassioned hunters" in Spain and Portugal, is erroneous. Even in France the wild boar is now very rarely met with. The Indian group contains in all six species, of which three have been recently discovered by Salomon Müller; but none of these can be compared in size and ferocity to the European wild boar. The Indian swine are distributed not only over the Asiatic Archipelago and the peninsula of Malacca, but also over the Island of Papua. *Sus babiroussa* (babiroussa), the most strange of all the species, inhabits the Island of Celebes, Bouro, and some of the Xulla Islands; but it is not found either in Amboina, Ceram, Timor, or any of the greater western islands of the Asiatic Archipelago. The three species recently discovered by Salomon Müller are *Sus verrucosus, timonensis,* and *barbatus* (white boar of Borneo). *Sus papuensis* (Papuan hog), which forms a passage to the American genus, *dicotyles,* is very common in the forests of New Guinea. In the south African group *Sus larvatus* (masked boar, wood swine, or Bosch vark) extends from the woods of Sitsikama, through the south-eastern part of Africa, and is the only pachydermatous animal found in the Island of Madagascar.

6. *Phascochoerus* (wart hogs). These animals belong exclusively to Africa, and extend from Senegambia and Abyssinia to the coasts of the Cape Colony; but within these limits they are very rare, occurring chiefly in remote regions. *Phascochoerus æthiophicus* (South African phascochoerus, vlake vark or African boar, is found along the River Senegal, in Guinea, and through the whole of Central Africa, from the table-land of Abyssinia to the Cape Colony. Two others are found in Abyssinia, and *Phascochoerus Aeliani s. Africanus* (Abyssinian wart hog) occurs also in Kordofan.

7. *Dicotyles* (peccaries). These are the only indigenous representatives of the porcine group in the New World. *Dicotyles torquatus* (collared peccary—taytitou of the Guarinis), is an inhabitant of the dense forests throughout the greater part of South America, from the peninsula of Yucatan, in Central America, to Paraguay. This species climbs the eastern slopes of the Andes to a height of six thousand feet. *Dicotyles labiatus* (white lipped peccary, or tajassu), is a native of the countries of Guayana and Paraguay. These animals assemble in vast troops, sometimes in thousands at a time, and are said to be led generally by an old male.

8. *Tapirus* (tapirs). In as far as yet ascertained, this genus contains only three species, of which two are natives of South America, and the other of the Asiatic Archipelago. This is the only thick-skinned animal which is common to both the Old and the New World. *Tapirus Malayanus s. Indicus* (the Malay tapir) inhabits the forests of Malacca, Sumatra, and the northern part of Borneo, which it seldom leaves. On the west coast of Sumatra this animal is found at a height of nearly four thousand feet. According to Abel Remusat, a species of tapir is found in the south-western provinces of China; whether this be the Malay tapir, or a new species, *Tapirus Chinensis,* is not yet ascertained. Of the

two American species, *Tapirus Americanus* (the common American tapir) is distributed over the countries from Nicaragua, about latitude 14° north, to the pampas of La Plata, about latitude 40° south. It ascends the Andes to as great a height as the peccaries. The second species, *Tapirus pinchaque*, which was only lately discovered, inhabits chiefly the most elevated parts of the Andes of New Granada.

9. *Equus* (horse). The animals of this genus are very characteristically divided into three principal groups:—1*st*, Group of the *proper horses; 2d*, *Asinine group* (asses); 3*d*, *Hippotigrine group* (zebras). These animals, in a domesticated, as well as in a wild state, are distributed over the whole globe. In our map the first group is entirely omitted, in order to admit of greater clearness in the representation of the other genera of the Pachydermata. Besides, it would have been impossible clearly to separate the distribution of the original wild horse from the feral, or that which had once been domesticated, but has again returned to a state of nature.[1] On the contrary, the second group, that of the wild ass, which is characteristic of the great highlands and deserts of the interior of Asia; and the third group, that of the zebra, which is peculiar to Africa, have their limits so fixed by nature, as to admit of being delineated on the map with considerable minuteness. The wild asses, which, on the map, are all comprehended under the species *Equus asinus onager*, and are included within the same boundaries, extend over the countries from Siberia to Egypt. There prevails, however, a great confusion among the different species, occasioned by the great number of names which are applied to them; and on this account it is often difficult to decide whether two supposed species are the same animal under different names, or, if different, in what the difference consists, or even whether a particular species belongs to the horse or the asinine group. On this account we have only given the names of those which are well known in the countries where they occur. *Koulan* (the wild ass of the Tartars), which is regarded as the origin of the common ass, inhabits the dry mountainous parts of Great Tartary, where, in summer, it ranges as far as latitude 48° north, returning southward with the change of season. Whole herds of them may be seen in motion as far as the deserts of the Lower Indus; but they are distributed chiefly over the eastern provinces of Persia. *Equus asinus hemionus* (djiggetai of the Mongols) *Mulus, dauricus, cappadocius*, Kitchera, extends northwards into southern Siberia, and is spread over the Desert of Gobi. It is abundant in Thibet, and in the regions of the Himalayan Mountains, and is not unknown in India, unless it is there perhaps confounded with the *Asinus equuleus*. *Equus asinus equuleus* (yo-to-tze of the Chinese?) is said to have been brought from the Chinese frontiers north-east of Calcutta; and to inhabit different parts of Chinese Tartary, but very little is known of its distribution. The principal remaining species are, the *ghoor-khur* of Afghanistan and the banks of the Indus and Persia, where it is confounded with the hamar or ahmar (djaar of the Arabs and Mograbins, and daja-ischake of the Turks); the *Equus kiang* of the Himalayan Mountains, discovered and named by Moorcroft. The wild ass of Cutch and northern Gujerat, which Colonel Sykes identifies with the djiggetai and ghoor-khur, is not found farther eastward than longitude 75°, on the southern side of the Himalayan Mountains; it especially frequents the salt deserts and open plains of Jodhpoor, Jaysulmeer, and Bickaneer.

Of the zebras, some of which prefer mountainous districts, and others the upland plains, the first species, *Equus zebra s. montanus* (zebra), extends from the territory of the Cape of Good Hope north-eastward, beyond the country of Mozambique, probably as far as the southern mountains of Abyssinia; it occurs also in Congo and Guinea. *Equus burchellii* (hippotigris antiquorum—dauw of the South African colonists), is an inhabitant of the plains, and occurs in every district north of the River Gariep, extending probably from Congo eastwards to the Galla country. It is especially abundant in the province of Bamba, in Congo. *Equus quagga* (the quagga) is a native of the plains, and is found to the south of the Gariep River, within the limits of the Cape Colony.

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[1] It is well known that the horses of Texas, Cuba, S. Domingo, and the pampas of La Plata, in the New World; and those of the western coast of Africa, Celebes, &c., in the Old World, introduced to these countries in a domesticated state by the original colonists or conquerors, have, when left to spread themselves over uninhabited districts, returned to the wild state.

ZOOLOGICAL GEOGRAPHY.

SHEET No. II.

THE GEOGRAPHICAL DIVISION AND DISTRIBUTION OF MAMMIFEROUS ANIMALS,

OF THE ORDER

CARNIVORA (CARNIVOROUS ANIMALS).

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SECTION I.

CLASSIFICATION AND GENERAL REMARKS ON DISTRIBUTION.

The animals treated of in this section have, in all ages, been objects of peculiar interest to mankind, sometimes on account of their strength, magnanimity, and valour, but more frequently because of their cruelty, their cunning, and their blood-thirsty habits.

The term Carnivora, in zoology, is used generally to designate all creatures that feed on flesh or animal substances; but it is more especially applicable to that order of mammiferous quadrupeds which feed on other animals, and to which Cuvier has given the name of Carnassiers (flesh-eaters).

This order is divided into the following families:—

1. Chiroptera.
2. Dermoptera.
3. Insectivora.
4. Plantigrada.
5. Digitigrada.
6. Pinnipedia.

The sixth family, that of the *Pinnipedia*, comprising the genera *Phoca* and *Trichechus* (seals and morses) whose habitat is in the sea, is excluded from this section, which treats of the first five families comprising the Land-Carnivora. According to the latest authorities, and the most careful calculations, these five families contain, in all, 514 known and described species, forming one-third of all Mammalia These 514 species are divided into 61 genera, in the following manner:—

	Number of Species.
I. CHIROPTERA,	**219**
A. Frugivora (Frugivorous Bats).	
1. Pteropus (Roussette Bats),	30
2. Pachysoma (Stout-bodied Roussettes),	6
3. Macroglossus (Great-tongued Roussettes),	1
4. Harpyia (Tube-nosed Roussettes),	1
5. Cephalotes (Cephalotes),	1
B. Insectivora (Insectivorous Bats).	
6. Dysopes (Bull-dog Bats),	17
7. Diclidurus (Fox-tailed Bats),	1
8. Noctilio (Hare-lipped Bats),	2
9. Vampyrus (Vampyre Bats),	1
10. Phyllostoma (Javelin Bats),	13
11. Glossophaga (Long-tongued Bats),	4
12. Megaderma (Broad-winged Bats),	3
13. Rhinolophus (Horse-shoe Bats),	20
14. Nyctophilus (South-Sea Bats),	1
15. Nycteris (Cheek-pouched Bats),	6
16. Desmodus (Curved-tooth Bats),	3
17. Rhinopoma (Lid-nose Bats)	1
18. Taphozous (Wing-pouched Bats),	9
19. Mormoops (Mormoops Bats),	1
20. Emballonura (Long-nosed Bats),	5
21. Nycticejus (Roquet-dog Bats)	11
22. Vespertilio (Bats proper),	81
23. Furia (Fury Bats),	1

	Number of Species
II. DERMOPTERA,	**5**
24. Galeopithecus (Vaulting or Flying Cats),	5
III. INSECTIVORA,	**61**
25. Erinaceus (Hedgehogs),	5
26. Sorex (Shrews),	26
27. Hylogale (Banxrings),	4
28. Hylomys (Hylomys),	1
29. Gymnura (Oriental Hedgehogs),	1
30. Mygale (Desmans),	2
31. Scalops (Scalopes),	1
32. Macroscelides (Cape-Elephant Shrews),	5
33. Chrysochloris (Chrysochloris),	4
34. Centetes (Tenrecs),	4
35. Talpa (Moles),	4
36. Condylura (Condylures or star-nosed Moles),	4
IV. PLANTIGRADA,	**34**
37. Ursus (Bears),	12
38. Procyon (Racoons),	2
39. Ailurus (Pandas),	1
40. Nasua (Coatis),	6
41. Arctitis (Benturongs),	4
42. Cercoleptes (Kinkajous or Potos),	2
43. Meles (Badgers),	2
44. Gulo (Gluttons),	5

	Number of Species.
V. DIGITIGRADA,	**195**
45. Mustela (Martens),	28
46. Mydaus (Teledus, Telagons, or Stinkards),	2
47. Mephitis (Skunks),	15
48. Lutra (Otters),	17
49. Canis (Dogs),	41
50. Viverra (Civets),	15
51. Cryptoprocta (Cryptoproctas),	1
52. Patamophilus (Patamophiles),	1
53. Linsang (Linsangs or Delundungs),	1
54. Paradoxurus (Paradoxures),	4
55. Herpestes (Ichneumons),	10
56. Ryzaena (Suricates),	2
57. Proteles (Proteles),	1
58. Cynictis (Cynictis),	1
59. Bassaris (Bassaris),	1
60. Hyæna (Hyænas),	4
61. Felis (Cats),	51

From the presence of carnassiers, or flesh-eaters, in any particular region or quarter of the globe, we may conclude the prevalence of the weaker classes of animals, since it is from the latter chiefly that they derive their nourishment; and a simple inspection of the map will show that the great seat of the carnivorous tribe is in the tropical regions, thus confirming the general law referred to in the notes to the first sheet of this division, namely, that animal formations increase in proportion as we advance from the arctic and temperate regions of the globe towards the equator. But this general law is reversed, as already mentioned, in the case of the marine Mammalia, or animals of higher organization which inhabit the sea, since these are found to decrease in proceeding from the arctic to the tropical regions; and even in the case of the Land-Carnivora this law suffers a remarkable exception; for there is a region within the tropics which is characterized by a great deficiency in animals of the carnivorous order: this is the Oceanic province, which embraces New Guinea and the adjacent islands.

In the same longitude, and chiefly within the tropics, is situated the Australian region, which, as containing the minimum number of Carnivora, is distinguished by the lightest shading on the map, a reference to which will show the remarkable contrast which it forms with the regions of Africa and South America, situated in the same parallel of latitude.

In so far as ascertained, animals of the order Carnivora are spread over the whole globe—their occurrence has no limits, but their distribution among the different countries and regions is very irregular. This will be best understood by a reference to the following arrangement:—

DIVISION OF THE GLOBE INTO ZOOLOGICAL KINGDOMS AND PROVINCES.

The surface of the globe may be arranged in certain zoological kingdoms, and these may again be subdivided into provinces, as has been done by Zimmerman, Illiger, Minding, and latterly by Swainson and Schlegel. Following this example, we shall divide the earth into *five* great zoological kingdoms, which correspond in extent with the five principal divisions of the globe.

1. The *first* kingdom embraces Europe, which is divided into the Northern, Middle, and Southern provinces. The limit between the Northern and Central provinces falls about latitude 60° north, or more accurately, it coincides with the curve of 41° mean annual temperature. The separation between the Central and Southern provinces is formed by the chains of the Pyrenees and the Alps; the peninsulas of Spain, Italy, and Greece, with the islands of the Mediterranean, form the Southern province, which, in the East, is divided by the Ural Mountains from the

2. *Second* kingdom, comprising Asia. At the junction of Europe and Asia, on the coasts of the Black Sea and the Caucasus, the European and Asiatic forms of animals are mixed, and pass into each other. There is here a peculiar zoological district, consisting of Anterior Asia, or the countries of the Caucasus, Asia Minor, Syria, and the table-lands of Iran (Persia), which we have designated by the name of the European-Asiatic Transition province, in which are also found specimens of the zoological characters of Africa. Asia is divided also into three provinces—the Northern, Middle, and Southern. The Northern province extends from the Volga in the west, to the mountain range of the Altai, with a mean temperature of 42°; and eastward to the shores of the Pacific Ocean, where it is bounded by the isotherm curve of 32°, which marks the limit of the permanent frost of the ground. This province includes the whole of Siberia, Kamtchatka, &c. The Central province is limited on the south side by the Himalayan Mountains, consequently it comprises all Asia from the Caspian Sea to the Pacific Ocean including the islands of Japan, &c. Beyond the Himalaya begins the Southern province, or the Indian world, comprising both peninsulas, a part of the Southern province of China, and the whole Archipelago. The south-eastern extremity of the zoological region of Asia is so strictly defined by the Moluccas and Timor, that whilst on these islands there is a great abundance of Carnivora and other orders of animals, on New Guinea, separated from them only by a small arm of the sea, they appear to be almost or entirely wanting. We have now reached the Oceanic province, already mentioned as being characterized by a great deficiency of carnivorous animals; southward from it lies the

3. *Third* zoological kingdom, or Australia, which, besides the continent of Australia and Van Diemen's Land, comprises the islands to the eastward, including New Zealand, and the numerous small groups of Polynesia; and these, from the small extent of space to which they are confined, the uniformity of the soil, climate, and produce, and the consequent uniformity of the animal world, form only one province.

4. The *fourth* kingdom consists of Africa, the peninsula of Arabia, which in its natural character is so closely connected with it, and the islands of Madagascar, Bourbon, and Mauritius.

5. The *fifth* kingdom consists of North and South America, or the New World, and is divided into four provinces, namely, those of Arctic, Northern, Tropical, and Southern America. The Arctic is divided from the Northern province by a curved line beginning about Prince of Wales Island, on the west, and passing eastward through the middle of the Canadian lakes; this line coincides with the isotherm curve of 46°, and the province is chiefly composed of British, and Russian America. The Northern province extends southward to the Gulf of Mexico, whence it is bounded by a line drawn from the mouth of the River Bravo del Norte to the northern extremity of the Gulf of California, and comprises the United States, Texas, and the greater part of Mexico. The Tropical province extends through Central America, the Antilles, and all South America, to the parallel of 40° south, where it is joined by the Southern province, which comprises Patagonia and the islands south to Cape Horn.

DIVISION AND INTENSITY OF THE GENERA AND SPECIES.

It has already been observed, that the Carnivora increase in a direction from the polar to the equatorial regions, and that the maximum number of their species is found in the countries within the torrid zone, with the remarkable exception of New Guinea and the adjacent islands, forming the Oceanic province. In the following table we have endeavoured to present a complete view of the families and genera of the Land-Carnivora, showing the number of their species in each of the fourteen zoological provinces.

TABLE SHOWING THE DIVISION OF THE *LAND-CARNIVORA* IN THE ZOOLOGICAL PROVINCES.

FAMILIES and GENERA OF THE LAND-CARNIVORA, WITH THE Number of their Species.	Zoological Provinces.													
	Austral Provinces.			Tropical Provinces.			Temperate Provinces.					Arctic Provinces.		
	Australia. 1	Oceanic Province. 2	South America. 3	Tropical America. 4	Tropical Africa. 5	Tropical Asia. 6	Central Asia. 7	Transition Province. 8	Southern Europe. 9	Central Europe. 10	North America. 11	Arctic America. 12	Arctic Europe. 13	Arctic Asia. 14
	Number of the Species.													
I. CHIROPTERA, 219	**3**	**25**	**1**	**55**	**41**	**67**	**12**	**7**	**22**	**20**	**10**	**1**	**7**	**6**
A. Frugivora (Frugivorous Bats.)														
1. Pteropus (Roussette Bats), **30**	1	13	.	.	10	12	2	.	.	.	.	.	.	.
2. Pachysoma (Stout-bodied Roussettes), **6**	.	.	.	.	.	* 6	.	.	.	.	.	.	.	.
3. Macroglossus (Great-tongued Roussettes), **1**	.	1	.	.	.	1	.	.	.	.	.	.	.	.
4. Harpyia (Tube-nosed Roussettes), **1**	.	1	.	.	.	1	.	.	.	.	.	.	.	.
5. Cephalotes (Cephalotes), **1**	.	1	.	.	.	1	.	.	.	.	.	.	.	.
B. Insectivora (Insectivorous Bats.)														
6. Dysopes (Bull-dog Bats), **17**	1	.	.	10	2	4	.	.	1	.	.	.	.	.
7. Diclidurus (Fox-tailed Bats), **1**	.	.	.	* 1	.	.	.	.	.	.	.	.	.	.
8. Noctilio (Hare-lipped Bats), **2**	.	.	.	* 2	.	.	.	.	.	.	.	.	.	.
9. Vampyrus (Vampyre Bats), **1**	.	.	.	* 1	.	.	.	.	.	.	.	.	.	.
10. Phyllostoma (Javelin Bats), **13**	.	.	.	* 13	.	.	.	.	.	.	.	.	.	.
11. Glossophaga (Long-tongued Bats), **4**	.	.	.	* 4	.	.	.	.	.	.	.	.	.	.
12. Megaderma (Broad-winged Bats), **3**	.	1	.	.	1	2	.	.	.	.	.	.	.	.
13. Rhinolophus (Horse-shoe Bats), **20**	.	5	.	.	3	12	2	3	4	2	.	.	.	1
14. Nyctophilus (South-Sea Bats), **1**	.	* 1	.	.	.	.	.	.	.	.	.	.	.	.
15. Nycteris (Cheek-pouched Bats), **6**	.	.	.	.	5	1	.	.	.	.	.	.	.	.
16. Desmodus (Curved-tooth Bats), **3**	.	.	.	* 3	.	.	.	.	.	.	.	.	.	.
17 Rhinopoma (Lid-nose Bats), **1**	.	.	.	.	* 1	.	.	.	.	.	.	.	.	.
18. Taphozous (Wing-pouched Bats), **9**	.	.	.	1	4	3	.	.	.	.	1	.	.	.
19. Mormoops (Mormoops Bats), **1**	.	.	.	* 1	.	.	.	.	.	.	.	.	.	.
20. Emballonura (Long-nosed Bats), **5**	.	.	.	4	.	1	.	.	.	.	.	.	.	.
21. Nycticejus (Roquet-dog Bats), **11**	.	1	.	2	3	4	.	.	.	.	3	1	.	.
22. Vespertilio (Bats proper), **81**	1	1	1	12	12	19	8	4	17	18	6	.	7	5
23. Furia (Fury Bats), **1**	.	.	.	* 1	.	.	.	.	.	.	.	.	.	.
II. DERMOPTERA, 5	.	.	.	.	.	* 5	.	.	.	.	.	.	.	.
24. Galeopithecus (Vaulting or Flying Cats), **5**	.	.	.	.	.	* 5	.	.	.	.	.	.	.	.
III. INSECTIVORA, 61	.	.	.	**4**	**25**	**15**	**11**	**4**	**6**	**10**	**8**	**7**	**3**	**6**
25. Erinaceus (Hedgehogs), **5**	.	.	.	1	2	1	1	1	1	2	.	.	1	.
26. Sorex (Shrews), **26**	.	.	.	2	10	8	9	2	2	5	2	2	1	5
27. Hylogale (Banxrings), **4**	.	.	.	.	.	* 4	.	.	.	.	.	.	.	.
28. Hylomys (Hylomys), **1**	.	.	.	.	.	* 1	.	.	.	.	.	.	.	.
29. Gymnura (Oriental Hedgehogs), **1**	.	.	.	.	.	* 1	.	.	.	.	.	.	.	.
30. Mygale (Desmans), **2**	.	.	.	.	.	.	.	1	1	2	.	.	.	.
31. Scalops (Scalopes), **1**	.	.	.	.	.	.	.	.	.	.	1	1	.	.
32. Macroscelides (Cape-Elephant Shrews), **5**	.	.	.	.	* 5	.	.	.	.	.	.	.	.	.
33. Chrysochloris (Chrysochloris), **4**	.	.	.	1	3	.	.	.	.	.	.	.	.	.
34. Centetes (Tenrecs), **4**	.	.	.	.	* 4	.	.	.	.	.	.	.	.	.
35. Talpa (Moles), **4**	.	.	.	.	1	.	1	.	2	1	2	.	1	1
36. Condylura (Condylures or star-nosed Moles) **4**	.	.	.	.	.	.	.	.	.	.	3	4	.	.
IV. PLANTIGRADA, 34	.	.	.	**12**	**2**	**11**	**7**	**4**	**2**	**3**	**5**	**5**	**4**	**5**
37. Ursus (Bears), **12**	.	.	.	1	1	5	6	3	1	2	2	2	3	3
38. Procyon (Racoons), **2**	.	.	.	2	.	.	.	.	.	.	1	.	.	.
39. Ailurus (Pandas), **1**	.	.	.	.	.	* 1	.	.	.	.	.	.	.	.
40. Nasua (Coatis), **6**	.	.	.	5	.	.	.	.	.	.	1	.	.	.
41. Arctitis (Benturongs), **4**	.	.	.	.	.	4	1	.	.	.	.	.	.	.
42. Cercoleptes (Kinkajous or Potos), **2**	.	.	.	* 2	.	.	.	.	.	.	.	.	.	.
43. Meles (Badgers), **2**	.	.	.	.	.	.	.	1	1	1	.	1	.	1
44. Gulo (Gluttons), **5**	.	.	.	2	1	1	.	.	.	.	1	2	1	1
V. DIGITIGRADA, 195	**1**	**2**	**12**	**38**	**62**	**68**	**25**	**25**	**12**	**13**	**27**	**23**	**17**	**19**
45. Mustela (Martens), **28**	.	.	.	2	6	7	6	5	4	6	4	8	6	5
46. Mydaus (Teledus, Telagons or Stinkards), **2**	.	.	.	.	.	* 2	.	.	.	.	.	.	.	.
47. Mephitis (Skunks), **15**	.	.	4	11	1	.	.	.	.	.	5	2	.	.
48. Lutra (Otters), **17**	.	.	3	5	3	5	3	1	.	2	5	4	2	2
49. Canis (Dogs), **41**	1	1	3	8	11	8	5	4	4	3	10	7	5	6
50. Viverra (Civets), **15**	.	.	.	.	11	8	.	2	1	.	.	.	.	.
51. Cryptoprocta (Cryptoproctas), **1**	.	.	.	.	* 1	.	.	.	.	.	.	.	.	.
52. Patamophilus (Patamophiles), **1**	.	.	.	.	.	* 1	.	.	.	.	.	.	.	.
53. Linsang (Linsangs or Delundungs), **1**	.	.	.	.	.	* 1	.	.	.	.	.	.	.	.
54. Paradoxurus (Paradoxures), **4**	.	1	.	.	.	4	.	.	.	.	.	.	.	.
55. Herpestes (Ichneumons), **10**	.	.	.	.	5	5	.	2	.	.	.	.	.	.
56. Ryzaena (Suricates), **2**	.	.	.	.	* 2	.	.	.	.	.	.	.	.	.
57. Proteles (Proteles), **1**	.	.	.	.	* 1	.	.	.	.	.	.	.	.	.
58. Cynictis (Cynictis), **1**	.	.	.	.	* 1	.	.	.	.	.	.	.	.	.
59. Bassaris (Bassaris), **1**	.	.	.	* 1	.	.	.	.	.	.	.	.	.	.
60. Hyæna (Hyænas), **4**	.	.	.	.	4	.	1	1	.	.	.	.	.	.
61. Felis (Cats), **51**	.	.	2	11	16	17	10	10	3	2	3	2	4	6
AMOUNT OF THE SPECIES OF ALL LAND-CARNIVORA, **514**	**4**	**27**	**13**	**109**	**130**	**166**	**55**	**40**	**42**	**46**	**50**	**36**	**31**	**36**

Wherever this mark * occurs, the animal referred to belongs exclusively to the province indicated.

The same information which is contained in the foregoing table is given in the small tablets placed upon each zoological province in the map; but the latter present only a view of the Carnivora belonging to each separate province, whilst the above table shows at once over which province any given family or genera is distributed. This table contains a complete key for the use of those who take an interest in such inquiries—affording the means of instituting the greatest number of comparisons as to the proportions in which the entire number of Carnivora are distributed in the different provinces, the proportions which the single families and genera bear to each other in the zoological kingdoms or provinces of the same zone, &c. It may, therefore, be regarded as directing attention to some of the most important data requisite for the further elucidation of zoological geography. The figures at the foot of the table show the total number of carnivorous animals in each province; since, however, the provinces are there arranged in succession, according to zones, we have prepared the following scale, which is so arranged as to show the proportions, in an ascending order, from that province which contains the smallest to that which contains the greatest number of species, or from Australia to Tropical Asia.

Australian Provinces,	1. Australia,	4 species.
	3. South America,	13 „
	2. Oceanic Province,	27 „
Arctic Provinces,	13. Arctic Europe,	31 „
	14. Arctic Asia,	36 „
	12. Arctic America,	36 „
Temperate Provinces,	8. Transition Province,	40 „
	9. Southern Europe,	42 „
	10. Central Europe,	46 „
	11. North America,	50 „
	7. Central Asia,	55 „
Tropical Provinces,	4. Tropical America,	109 „
	5. Tropical Africa,	130 „
	6. Tropical Asia,	166 „

From this scale we see that the provinces of the same zone, in different parts of the earth, resemble each other in the number of species which they contain, but that the Tropical provinces are so completely distinguished from the adjoining Temperate provinces, that in all cases the former contain nearly *three times* as many species as the latter. For example, Tropical Asia contains 166 species, while the adjoining Temperate province, Central Asia, contains only 55 species, or about a third part of the number. The same proportion is observed between the two remaining Tropical provinces and the Temperate provinces by which they are limited; but the most remarkable difference is that which is observed between the Asiatic Tropical province and the two Austral provinces which border upon it, since Tropical Asia contains *thirteen* times more Carnivora than the Oceanic province, and *forty-one and-a-half* times more than Australia. In regard to the five separate families, we find that two of them are distributed over all the provinces, namely, those of the *Chiroptera* and the *Digitigrada;* that the families of *Insectivora* and *Plantigrada* are, with the exception of the three Austral provinces, also spread over all the provinces; and that only the smallest of all the families, namely, that of the *Dermoptera*, consisting of one genus and five species, is limited to a single province.

I. FAMILY CHIROPTERA.

On consulting the following scale, which shows the division of the Chiroptera in the provinces, and which is constructed on the same principle as the former, it is especially worthy of remark that the Oceanic province possesses, with the exception of the three Tropical provinces, the greatest number of species, and that besides the two species of the family of Digitigrada, these are the only Carnivora found in this province. The greater number of these occur on the islands which form the transition to the Asiatic Tropical province; for in the small group of the Banda Islands and Amboina alone there are found sixteen species; and the remaining seven species are spread over the wide district of the Oceanic province from New Guinea to the Mariana Islands on the north, and to the Friendly Islands on the east. The Roussette bats, especially, are found in nearly as great numbers in this as in the Tropical provinces of Asia and Africa.

The most extensive genus of the Chiroptera—the common bats, the species of which form more than one-third of the entire family—has also the widest district of distribution, since, with the exception of Arctic America, it extends over all the zoological provinces. It forms the southernmost limit of the family of Chiroptera in the New World, where, on the Island of Chiloë, Mr Darwin discovered a new species of Vespertilio, during the recent voyage of the "Adventure and Beagle," which has so greatly contributed to the advancement of every branch of natural science.

SCALE OF INCREASING DENSITY OF CHIROPTERA IN THE FOURTEEN ZOOLOGICAL PROVINCES.

No. of Province.		Species.
3.	Southern America,	1
12.	Arctic America,	1
1.	Australia,	3
14.	Arctic Asia,	6
13.	Arctic Europe,	7
8.	Transition Province,	7
11.	North America,	10
7.	Central Asia,	12
10.	Central Europe,	20
9.	Southern Europe,	22
2.	Oceanic Province,	25
5.	Tropical Africa,	41
4.	Tropical America,	55
6.	Tropical Asia,	67

II. FAMILY DERMOPTERA.

As has been already remarked, the animals belonging to this family are restricted to a single province—that of Tropical Asia.

III. FAMILY INSECTIVORA.

The Insectivora differ from all the other families in this respect, that they do not follow with such regularity the general law, according to which the greatest numbers should be found under the tropics; for in the Tropical province of America only four species occur, whilst in the Temperate province there are eight, and in the Arctic province seven species. In the Old World they follow the general law of density in tropical climates, but differ from the other families in having the greatest number of species in Tropical Africa, whilst the maximum of all the others occurs in Tropical Asia.

The most extensive genus of the Insectivora, the *shrews*, has also, like the genus vespertilio in the family of Chiroptera, the widest circle of distribution; since, with the exception of the Austral provinces, it is found in all the zoological provinces, and is especially numerous in Africa and Asia. The moles and hedgehogs are also distributed over one-half of all the provinces.

SCALE OF INCREASING DENSITY OF INSECTIVORA IN THE FOURTEEN ZOOLOGICAL PROVINCES.

No. of Province.		Species.
1. 2. 3.	Austral Provinces,	0
13.	Arctic Europe,	3
8.	Transition Province,	4
4.	Tropical America,	4
14.	Arctic Asia,	6
9.	Southern Europe,	6
12.	Arctic America,	7
11.	North America,	8
10.	Central Europe,	10
7.	Central Asia,	11
6.	Tropical Asia,	15
5.	Tropical Africa,	25

IV. FAMILY PLANTIGRADA.

This family restores the general balance in the distribution of species, which was disturbed by the three previous families; since Africa, which contains the greatest number of Insectivora, has, of all the provinces, the fewest Plantigrada. There is one remarkable feature in their distribution, namely, that Africa, together with Europe, under the same longitude, contains, in comparison with the other parts of the earth, the fewest species of Plantigrada, and that here, instead of increasing in the direction of the equator, they are found to increase towards the poles. This arises from the genus of the proper bears, whose habitat is confined chiefly to the frigid zone. The Asiatic world and America nearly resemble each other in the distribution of species; but Tropical and Central Asia are especially rich in species of the genus ursus.

SCALE OF INCREASING DENSITY OF PLANTIGRADA IN THE FOURTEEN ZOOLOGICAL PROVINCES.

No. of Province.		Species.
1. 2. 3.	Austral Provinces,	0
9.	Southern Europe,	2
5.	Tropical Africa,	2
10.	Central Europe,	3
8.	Transition Province,	4
13.	Arctic Europe,	4
14.	Arctic Asia,	5
11.	North America,	5
12.	Arctic America,	5
7.	Central Asia,	7
6.	Tropical Asia,	11
4.	Tropical America,	12

V. FAMILY DIGITIGRADA.

This last family, although not quite so numerous as that of the Chiroptera, is the most important since it contains the most powerful and ferocious of all carnivorous animals. It is distributed throughout all the zoological provinces, although by far the greater number occurs in the countries under the tropics, whence it gradually decreases, both in the number of species and the size of individuals, in the direction of the poles. In the New World, however, this gradual decrease towards the poles is more regular than in the Old World, where, in Africa, there are 62, and in Southern Europe only 12 species, being five times more numerous in the former than in the latter country, in equal latitudes. In Tropical Asia there are 68, and in Central Asia 25 species; or nearly three times more in the former than in the latter province.

Canis and *Felis* (the dog and cat tribes) are the two most important and numerous genera of the Digitigrada, and have also the widest circle of distribution, although the two provinces of Australia and Oceania do not possess a single species of the genus felis, and only one species of the genus canis, which, with one species of the genus paradoxurus, is the only species of the Digitigrada found in these provinces. Next to these the genera of the martens and otters are distributed over the greatest number of provinces, the former especially in the temperate, and the latter in the torrid zone.

SCALE OF INCREASING DENSITY OF DIGITIGRADA IN THE FOURTEEN ZOOLOGICAL PROVINCES.

No. of Province.		Species.
1.	Australia,	1
2.	Oceanic Province,	2
3.	South America,	12
9.	Southern Europe,	12
10.	Central Europe,	13
13.	Arctic Europe,	17
14.	Arctic Asia,	19
12.	Arctic America,	23
8.	Transition Province,	25
7.	Central Asia,	25
11.	North America,	27
4.	Tropical America,	38
5.	Tropical Africa,	62
6.	Tropical Asia,	68

DIVISION OF THE GENERA IN THE OLD AND NEW WORLD.

Of the 61 genera of the Land-Carnivora very few are peculiar to either the Old or the New World as a whole, but many belong exclusively to the single provinces; thus we find that 28 of them, or nearly one-half of their number, are chiefly characteristic of the three Tropical provinces. We have prefixed a small asterisk (*) to the name of each of these in the table, page 2, which renders an enumeration of them here unnecessary. If we investigate the manner in which the Carnivora are divided in the Old and the New World, we shall find that only 17 genera belong in common to both hemispheres, and that of the remaining 44, 14 characterize the New, and 30 (or double the number) characterize the Old World. On examining the table, we find that those genera which are common to both hemispheres are distinguished by the number of their species, that those 17 genera contain 333 species, or nearly twice as many as the remaining 44 genera, which have in all only 181 species. In regard to the single families, we see that of all the Digitigrada hardly a single genus is peculiar to the New World; for the insignificant genus *Bassaris*, containing only one species, is not worth reckoning, whilst 11 genera, comprising 42 species, are peculiar to the countries of the Old World.

TABLE SHOWING THE DISTRIBUTION OF THE GENERA IN THE OLD AND NEW WORLD.

GENERA PECULIAR TO THE OLD WORLD.	Number of Species.	GENERA PECULIAR TO THE NEW WORLD.	Number of Species.
I. CHIROPTERA.			
A. Frugivora.			
1. Pteropus	30		
2. Pachysoma,	6		
3. Macroglossus,	1		
4. Harpyia,	1		
5. Cephalotes,	1		
B. Insectivora.			
12. Megaderma,	3	7. Diclidurus	1
13. Rhinolophus,	20	8. Noctilio,	2
14. Nyctophilus,	1	9. Vampyrus,	1
15. Nycteris,	6	10. Phyllostoma,	13
17. Rhinopoma,	1	11. Glossophaga,	4
		16. Desmodus,	3
		19. Mormoops,	1
		23. Furia,	1
II. DERMOPTERA.			
24. Galeopithecus,	5		
III. INSECTIVORA.			
27. Hylogale,	4	31. Scalops,	1
28. Hylomys,	1	36. Condylura,	4
29. Gymnura,	1		
30. Mygale,	2		
32. Macroscelides,	5		
34. Centetes,	4		
IV. PLANTIGRADA.			
39. Ailurus,	1	38. Procyon,	2
41. Arctitis	4	40. Nasua,	6
		42. Cercoleptes,	2
V. DIGITIGRADA.			
46. Mydaus,	2	59. Bassaris,	1
50. Viverra,	15		42
51. Cryptoprocta,	1		
52. Patamophilus,	1		
53. Linsang,	1		
54. Paradoxurus,	4		
55. Herpestes,	10		
56. Ryzaena,	2		
57. Proteles,	1		
58. Cynictis,	1		
60. Hyæna,	4		
	139		

GENERA WHICH ARE COMMON TO THE OLD AND THE NEW WORLD

I. CHIROPTERA. B. Insectivora.	Number of Species.
6. Dysopes.	17
18. Taphozous,	9
20. Emballonura,	5
21. Nycticejus,	11
22. Vespertilio,	81
III. INSECTIVORA.	
25. Erinaceus,	5
26. Sorex,	26
33. Chrysochloris,	4
35. Talpa,	4
IV. PLANTIGRADA.	
37. Ursus,	12
43. Meles,	2
44. Gulo,	5
V. DIGITIGRADA.	
45. Mustela,	28
47. Mephitis,	15
48. Lutra,	17
49. Canis,	41
61. Felis,	51
	333

DISTRIBUTION OF THE SINGLE GENERA AND SPECIES.

I. FAMILY CHIROPTERA.

As shown in the preceding section, the Chiroptera are spread over all the provinces; but of the two subdivisions, the frugivorous bats occur only in the Old World, whilst the insectivorous bats, although common to the Old are more characteristic of the New World.

A. Frugivora (Frugivorous Bats), so named from the circumstance of their feeding almost exclusively on fruits, have a district extending from Africa on the west, over Madagascar, Bourbon, Mauritius, India, and the Indian Archipelago, to Australia and Van Diemen's Land on the east; and over the Pacific Ocean, from the Friendly Islands in the south, to Japan on the north.

1. *Pteropus* (roussette bats). These have the widest district of distribution of any of the five genera which belong to the first subdivision, since they occupy the same limits as the entire group. Of the thirty species of pteropus, one of the most remarkable as well as the largest known species, is *Pteropus edulis* (edible roussette or kalong), which is limited to the islands of Java, Sumatra, and Banda. These bats are generally seen in great companies, consisting of hundreds or even thousands at a time; and this is also the case with other large species, as *Pteropus phacops* and *Pteropus funereus*. The districts inhabited by all the single species occurring in the groups of islands in the Pacific Ocean and Australia, as well as some other remarkable species, are defined on the map, from which it will be observed that the common roussette (*Pteropus vulgaris*) is limited to the very small district of the islands of Bourbon and Mauritius.

2. *Pachysoma* (stout-bodied roussettes). These bats are peculiar to the Tropical province of Asia; they do not live on trees like the pteropi, but in holes and crevices of the earth. The greater number of species occur in the islands of Java and Sumatra.

3. *Macroglossus* (great-tongued roussette), consisting of only one species, is one of the family of Chiroptera, which is distributed over almost the whole of the Indian Archipelago, from Sumatra to the Moluccas.

4. *Harpyia* (tube-nosed roussettes), and 5. *Cephalotes* are also peculiar to the Indian Archipelago.

B. Insectivora (Insectivorous Bats.)

6. *Dysopes* (bull-dog bat) is an inhabitant of the tropical regions, and the warmest portions of the temperate zones both of the Old and the New World, but chiefly of the latter, where, in Brazil, 8 of the 17 species occur. Of those belonging to the Old World, the most northern is *Dysopes Cestonii*, which is found in Italy and Egypt.

The following 6 genera: *Diclidurus*, *Noctilio*, *Vampyrus*, *Phyllostoma*, and *Glossophaga*, belong exclusively to the Tropical province of America, and of the 31 species of which they consist, 18 are found in Brazil. The most remarkable genus is the vampyre bat (*vampyrus*), which, feeding on the blood of other animals, attacks all kinds of quadrupeds, and even man. Its habitat extends from the West Indies across the Isthmus of Darien, and through almost the whole of South America, with the exception of the western part of Ecuador and Bolivia to Paraguay. It was recently discovered by Mr Darwin, near Coquimbo in Chile.

12. *Megaderma* (broad-winged bats); and, 13. *Rhinolophus* (horse-shoe bats). These belong to the Old World, and 2 of the latter are found in Great Britain.—*Rhinolophus unihastatus: s. ferrum equinum* (greater horse-shoe bat), and *Rhinolophus bihastatus: s. hipposideros* (little horse-shoe bat). Of this genus, 13 species are known to belong to the Indian Archipelago.

Of the remaining genera, the most common in the East Indies is

21. *Nycticejus* (roquet-dog bat), which is found in great multitudes, from the sea-shores to the interior of almost all the islands.

22. *Vespertilio* (proper bats). This is the most numerous genus, and inhabits nearly all the countries of the globe, 23 species belong to the European fauna alone, and of these 13 are found in Great Britain, namely:—

Vespertilio noctula (Noctula Bat).
Vespertilio Leisleri (Leisler's Bat).
Vespertilio discolor (Parti-coloured Bat).
Vespertilio serotinus (Serotine Bat).
Vespertilio auritus (Long-eared Bat).
Vespertilio Nattereri (Natterer's Bat).
Vespertilio Daubentonii (Daubenton's Bat).
Vespertilio mystacinus (Whiskered Bat).
Vespertilio emarginatus (Notched-ear Bat).
Vespertilio pipistrellus (Pipistrella or Common Bat).
Vespertilio barbastellus (Barbastelle Bat).
Vespertilio Bechsteinii (Bechstein's Bat.)
Vespertilio murinus (Mouse-eared Bat).

The common bat is widely spread over all the northern parts of Europe, but is very rare in the south; it is probably also an inhabitant of Asia, at least some species have been brought from Japan.

II. FAMILY DERMOPTERA.

This is the smallest of all the families, consisting of the genus *Galeopithecus* (vaulting or flying cat), which inhabits exclusively the Tropical province of Asia. The best known species, namely, *Galeopithecus variegatus*, was observed by Salomon Müller, on the islands of Java, Sumatra, and Borneo; and it is said also to have been observed by Diard in Siam and the Peninsula of Malay. This most remarkable animal, which is about the size of a domestic cat, is of a wild and jealous disposition: when disturbed in its rest, it emits a peculiarly disagreeable screaming and chattering cry, and bites itself with rage. Another species is found in Gujerat, and also in the Philippine Islands.

III. FAMILY INSECTIVORA.

The animals of this order, as the name implies, are appointed to keep in check the overwhelming increase of the insect world.

25. *Erinaceus* (hedgehogs). This animal belongs mostly to the Old World; the European hedgehog occurs in most of the countries of Europe; it is distributed over the cultivated parts of England, and in the southern part of the middle division of Scotland, but is not found in the northern districts of the country, nor in the Northern or Western Islands.

26. *Sorex* (shrews). Of this, the most numerous genus of the Insectivora, three species belong to Great Britain; namely, *Sorex araneus* (common shrew), *Sorex fodiens* (water shrew), and *Sorex remifer* (oared shrew).

The habitat of the remaining genera, which are mostly confined to one or two zoological provinces, is shown in the table, page 2. We may, therefore, confine our remarks to the two genera which have the widest district of distribution, and are best known. Of these

30. *Mygale* (desmans), is an inhabitant of marshy and humid soils. *Mygale Moscovitica* (Muscovite desman), is abundant in the countries to the south of the Volga, and in the vicinity of Voronetz; the other species, *Mygale Pyrenaica* (Pyrenean desman), is found near Tarbes, in France.

35. *Talpa* (moles). *Talpa Europæa* (common mole), is one of the smallest, but most numerous of the Carnivora. It inhabits chiefly the countries of Central and Northern Europe, extending southward to the Pyrenees, the north of Italy and Greece, and eastward to Siberia. It is not known in the extreme north of Scotland, in the Orkneys, or Shetland Islands, nor in any of the Hebrides, excepting the Island of Bute. It is not found in any part of Ireland, but is common in all other parts of Great Britain.

IV. FAMILY PLANTIGRADA.

37. *Ursus* (bears). Europe, Asia, and America, have each their peculiar species of this genus. Its existence in Africa has long been a matter of doubt, but it is now ascertained that a species of bear is found, though rarely, in Abyssinia, in the chain of Mount Atlas, and in the Tetuan Mountains. *Ursus arctos* (brown bear), was formerly common in almost every country of Europe, but at present it is very seldom met with, except in the northern districts of Norway and Russia, where within the arctic circle, it probably extends through Siberia and Kamtchatka to Japan in the east. It is occasionally, though rarely, seen in the recesses of the Alps. In the Pyrenees and Asturian Mountains, is found the variety *Ursus Pyrenæus* (Pyrenean bear). Among the Asiatic bears, the most remarkable are: *Ursus Syriacus* (Syrian bear), which is but seldom met with. *Ursus Tibetanus* (Tibet bear), an inhabitant of the mountains of Silhet and Nepaul, and *Ursus Malayanus* (sun bear of Sumatra). Of the American bears, the most ferocious is *Ursus ferox* (the grizzly bear), a native of the Rocky Mountains, and the district to the eastward. It has been observed as far north as latitude 61°; and southwards, it is said to extend to the borders of Mexico. *Ursus Americanus* (the American black bear) inhabits all the wooded districts of the American continent, from the Atlantic to the Pacific Ocean, and from Carolina to the shores of the Arctic Ocean. *Ursus maritimus* (the polar bear, or white bear of the Icy Sea) inhabits all the northern regions of the globe on the shores of the Arctic Ocean, extending southwards, at farthest, to about latitude 65° north. It has been observed in Norway, Iceland, Greenland, and as far west as Barrow Strait.

38. *Procyon* (racoons). Notwithstanding Buffon's assertion to the contrary, the racoon inhabits Canada, as well as the warmer regions of America, its range being from about 50° north latitude, through Mexico, and the United States and South America to Paraguay.

43. *Meles* (badgers). The badger is distributed over all the countries of Europe and North-West Asia. It is the only species belonging to the family of the Plantigrada which now occurs in Britain, where, however, it is nowhere abundant, and in many districts is extremely rare.

44. *Gulo* (gluttons). The European glutton, the district of which is defined on the map, is most common in Norway, Northern Russia, and Siberia. In equally high latitudes in North America, there is found *Gulo luscus* (wolverine), and in South America, *Gulo vittatus* (grison).

V. FAMILY DIGITIGRADA.

This family comprehends the most sanguinary, and consequently the most typical of the Carnivora. The following are among the most remarkable and numerous of the genera:—

45. *Mustela* (martens). Except the three Austral, these are distributed over all the zoological provinces. Of the 28 species, 7 belong to Europe, and of these 4 are found in Great Britain, namely, *Mustela putorius* (fitchet, pole-cat, or foumart); *Mustela erminea* (stoat or ermine); *Mustela vulgaris* (weasel); and *Mustela foina* (fouine or beech marten). Of these 4 species, it appears that in England generally, the ermine is less common than the weasel; but in Scotland, even to the south of the Firth of Forth, the ermine occurs most frequently. The marten is common in England and Scotland. It is spread over the whole of Europe, especially in the northern districts. A detailed account of the distribution of these animals in the northern regions of Asia and America will be found in the description of the fur-bearing animals in the second section of this sheet.

46. *Mydaus* (teledus). This animal, which, in the Old World, occupies the place of the skunks in America, is confined to the islands of Java and Sumatra.

47. *Mephitis* (skunks) inhabit North and South America, from Canada to Chile.

48. *Lutra* (otters). *Lutra vulgaris* (common otter) is found generally in all the lakes and rivers of Europe, as well as on many parts of the coast. It is common on the shores of Scotland and Ireland, and on the rocky shores of the Hebrides and Shetland Islands.

49. *Canis* (dogs). This genus, the most useful to man in all conditions and in all climates, is spread over the whole globe, yet it (that is the wild dog, for domestic animals are not here spoken of) follows the general law of distribution, and increases in number from the polar to the equatorial regions. But, although the Tropical province of Asia contains, next to Africa, the greatest number of species, there appears to be a total absence of the dog tribe in India beyond the Ganges. And in the Indian Archipelago, generally so rich in Carnivora, only two species are known. In Australia and the Oceanic province, the genus Canis is represented by *Canis Novæ Hollandiæ* (dingo) which is spread over Australia, New Guinea, and New Britain. *Canis lupus* and *Canis vulpes* have the widest district of any of the dog tribe. *Canis lupus*, (wolf) the typical wolf of Europe and Asia, and the varieties belonging to this tribe in America, may be said to occupy both continents from the arctic circle on the north, to Spain and probably even to Marocco on the west; to Egypt, through Syria to beyond the Crishna in India on the east of the old continent; and to near the Isthmus of Panama in America. *Canis lupus vulgaris* (the common wolf). During the last century, this animal has been driven from the plains of Central Europe to the recesses of the Pyrenees and the Carpathian Mountains; but it is still found in Poland, some parts of Austria, France, Italy, and Spain; and is still common in Norway, Sweden, and Russia. *Canis vulpes vulgaris* (the common fox) is distributed over the greater part of Europe and Northern Asia, and is the only representative species of this genus in Great Britain. *Canis aureus* (jackal). This, which is the characteristic dog of Africa, has a district extending from the Senegal to India, and from Abyssinia and Caffraria to European Turkey and Southern Russia.

50. *Viverra* (civets). Of this genus, *Viverra genetta* (the genet) is found in the northern districts of Africa, in the south of France, and in the countries bordering on the Mediterranean; where, in Turkey, it is tamed and domesticated.

60. *Hyæna* (hyænas). The hyænas generally belong to the southern countries of Africa, but one species—*Hyæna striata s. vulgaris* (striped hyæna)—extends to Asia. It is spread over the countries from Soudan, Senegambia, and Abyssinia, over Barbary, Arabia, Nubia, Egypt, Syria, Asiatic Turkey, Persia, and India, northward to the Caucasian and Altaic Mountains.

61. *Felis* (cats). This genus, comprising the most powerful and ferocious of all predatory animals —including the lion, the king of beasts—is distributed over the whole globe. With the exception of the Oceanic province and Australia, the Islands of Japan, and probably the Philippine Isles, it is found in all the zones, extending to the limits of forests in the frigid zone. The species inhabiting America differ greatly in appearance from those of the Old World, and are in general smaller in size. None have yet been found on the western declivity of the Andes of Bolivia and Peru. *Felis leo* (lion) is spread over almost all the countries of Africa—from the Cape Colony to Barbary—except in the countries of the Nile, including Egypt from the Abyssinian plateau northward, and Darfur, Kordofan, and the Lybian Desert, where at present no lion is to be found. In Asia the lion is confined to a much smaller region, for its district extends only from Mount Zerda Koh, in the Persian plateau (latitude 32 north), to Gujerat, and the jungle countries of India and the districts bordering on the Euphrates. *Felis discolor s. concolor* (puma or cuguar) is the lion of the New World; it has a very extensive range over both continents of America. Towards the south it extends to Patagonia, in latitude 53° to 54° south; and in the north it extends on the one side to California, and on the other to Pennsylvania and the Canadian Lakes, in latitude 49° or 50° north. Nearly equal to the lion in strength, and perhaps excelling him in activity, *Felis tigris* (the royal tiger) is confined to the countries of Asia. Although the larger species of the cat tribe are limited in general to tropical countries, yet the royal tiger, which has its chief habitat in the sultry thickets of Bengal and the islands of Java and Sumatra, occasionally extends as far as the Altaic Mountains, whence it frequently makes incursions into Siberia, and beyond the Lake of Baikal. It is distributed over the countries, from Mount Zerda Koh, in Persia, eastwards to Corea, Siam, and Tonquin; and it is said to occur also in the south of China. The corresponding cat of the New World is *Felis onça* (the jaguar or American tiger), the principal habitat of which is Brazil and Paraguay. It extends southwards to the Rio Negro, and to Lake Nahual-Huassi (latitude 42° south), which derives its name from the Indian designation of the tiger. On the north it is not quite ascertained whether it extends to the borders of Mexico. Of the European cats, *Felis catus* (wild cat) is the only representative in Great Britain. It is spread over the greater part of Europe,—Germany, Hungary, Russia, and occurs also in Asia Minor. It is not found in the South of England, and but rarely appears in the wooded mountainous districts of Cumberland and Westmorland; but in the wild districts of the north of Scotland and in Ireland it is still abundant.

DISTRIBUTION OF THE CARNIVORA IN A PERPENDICULAR DIRECTION.

As intimated in the notes accompanying the first Map of Zoological Geography, we have endeavoured graphically to represent the distribution of Carnivora in mountainous regions; and although the observations on this subject are very deficient, we have been enabled to construct an interesting diagram, showing the elevation at which the different animals are found above the level of the sea, in the torrid and temperate zones. This diagram is constructed on the same scale as that on the Map of Botanical Geography (Pl. 25), and a similar method of representation is here employed; that is to say, that figures of the animals, drawn according to form and magnitude, in so far as the limited space would permit, are placed on the diagram at the height of their occurrence; and further, each of these is accompanied by a number referring to its name, at the foot of the design. The diagram represents four different regions or provinces, of which three belong to the Old and one to the New World.

I.—TEMPERATE ZONE OF EUROPE.

The nearest group, forming, as it were, the foreground of the picture, exhibits the Alps, and, as represented by them, the temperate zone. Here, in the Valley of Ursern, in the centre of an Alpine range (in the Swiss Canton of Uri), which, from its lowest point of 4,640 feet, rises, at the Hospice of St Gothard, to a height of 6,867 feet above the sea. Schinz observed the various carnivorous animals at the elevations mentioned under his name in the following table. The others were observed by Fitzinger in the Alps of the Archduchy of Austria, to a height of from 2,900 to 8,250 feet.

I. CHIROPTERA.

	Schinz.	Fitzinger.	
Rhinolophus ferrum equinum minor (Smaller Horse-Shoe Bat),		from 4500	to 8250 feet.
Vespertilio noctula (Noctula Bat),		4500	8250
Vespertilio serotinus (Serotine Bat),		4500	8250
Vespertilio murinus (Mouse-eared Bat),		2900	4500
Vespertilio (Bats proper),	7030		

III. INSECTIVORA.

	Schinz.	Fitzinger.	
Erinaceus Europaeus (European Hedgehog),		from 4500	to 8250 feet.
Sorex fodiens (Water Shrew),		2900	4500
Sorex araneus (Continental Shrew),		2900	4500
Sorex (Shrews),	7030		
Talpa (Moles),	7030		

IV. PLANTIGRADA.

	Schinz.	Fitzinger.	
Ursus arctos (Brown Bear),		from 4500	to 8250 feet.
Ursus niger (Black Bear),		4500	8250
Ursus Pyrenaeus (Pyrenean Bear),	8600		
Meles vulgaris (Common Badger),	6400	2900	4500

V. DIGITIGRADA.

	Schinz.	Fitzinger.	
Mustela putorius (Fitchet or Foumart),	5500	from 2900	to 4500 feet.
Mustela vulgaris (Weasel),	5500	2900	4500
Mustela erminea (Stoat or Ermine),	9600	4500	8250
Mustela martes (Common Marten),		4500	8250
Mustela Foina (Fouine),	5500	4500	8250
Lutra vulgaris (Common Otter),		4500	8250
Canis lupus vulgaris (Common Wolf),		4500	8250
Canis vulpes vulgaris (Common Fox),		4500	8250
Felis catus (Wild Cat),		4500	8250
Felis lynx (European Lynx),		4500	8250

These are all the observations on record for the region of the Alps; and from these it appears that Mustela erminea (the ermine), is found at the greatest elevation, preferring as its residence the region of the Alpine shrubs. Its habitat, as shown on the map, is beyond the lower limit of perpetual snow. The bear, not only in the Alps, but also in the Pyrenees, occupies the highest desert regions towards the snow line, chiefly at a height of 7,700 feet above the level of the sea. The lynx ascends the Pyrenees to the same height as in the Alps, namely, to 8,300 feet. In Northern Europe, Gulo borealis (the glutton) ascends the highest of the Scandinavian Alps, the forests of which are also inhabited by Canis lupus (the common wolf); but the latter frequently makes incursions into the plains, especially in winter, when the mountains are covered with snow.

II.—TORRID ZONE.

(a) ZOOLOGICAL PROVINCE OF TROPICAL ASIA.

This division is represented by the highest group in the background, and is surmounted by the Peak of Dhawalagiri. Salomon Müller, the indefatigable naturalist of the Indian Archipelago, is almost the only authority on whom we can rely for facts concerning the perpendicular distribution of the Carnivora in Tropical Asia. Of the

I. FAMILY CHIROPTERA, the genus *pteropus* inhabits chiefly the level districts of the country; hence it is often found in cultivated places, and even in the midst of the villages. Yet it is sometimes met with at a height of 4,200 feet. *Pachysoma* (stout-bodied Roussettes). These animals inhabit chiefly the hollows of the higher lying districts and mountain forests; and *Pachysoma titthecheilum* is found at the height of 6,400 feet. Of the *Rhinolophus* (horse-shoe bat) some species ascend to the height of 9,600 feet. Among the

V. FAMILY DIGITIGRADA, *Mustela Hardwickii* occupies a height of 8,000 feet. *Mydaus meliceps* (telagon or stinkard) is a true mountaineer, and in the great forests of the Sunda Islands travels to a height of 6,400 feet. *Lutra leptonyx* lives in the Island of Java, as well in the sluggish rivers of the plains as in the wild mountain torrents of the higher districts, where, in the rocky wooded hollows, it is found at a height of 2,600 feet. *Linsang gracilis* is found at a height of 1,900 feet. *Felis tigris* (the royal tiger) is found in the Islands of Java and Sumatra, from the sea-shore to a height of at least 3,800 feet, although never deep in the interior of forests, but generally on promontories and in thinly inhabited tracts, covered with low underwood, or where extensive fields of Alang-alang (Imperata Kœnigii) and other luxuriant plants of a shrub and tree-like form (Saccharum glaga, Eletheria coccinea pininga, &c.) cover the soil. On the continent of India, the tiger, as well as the leopard, travels in search of prey from the foot of the Himalayan Mountains to the upper regions, at an absolute elevation of 9,600 feet, where vegetation loses its tropical character, and assumes that of the temperate zone, where the wood consists almost entirely of rhododendron arboreum, quercus, acer, ulmus, and carpinus. The tiger, leopard, and panther frequent the naked woodless table-lands of Tibet, ascending in the clefts of the mountains to an elevation of 15,000 or 16,000 feet, equivalent to that of Mont Blanc. On comparing the principal habitat of the tiger in the plains of Bengal with its occurrence in the valleys of Dauria, and beyond Lake Baikal, it appears that it lives in isotherm latitudes, which range between the mean annual temperature of 81° and the freezing point (32°).

(b) ZOOLOGICAL PROVINCE OF TROPICAL AFRICA.

The small mountain on the right hand side of the diagram, containing only the figures of two animals, represents Africa. These two individuals belong to the

V. FAMILY DIGITIGRADA. The one is the *black-maned lion* of the Cape Colony, which is chiefly found in the open plains of the table-land. These plains stretch from the foot of the Wit and Winter Mountains, in the north-eastern districts of the Cape Colony, at an average height of 4,800 feet above the level of the sea. At the same elevation the *Hyæna venatica*, in great herds, not only pursues the peaceful antelope, but attacks the lion and the panther, which, notwithstanding their great strength, are overpowered by numbers, and fall in general an easy prey.

(c) ZOOLOGICAL PROVINCE OF TROPICAL AMERICA.

This province is represented on the left hand side of the diagram, crowned by Chimborazo, as representative of the chain of the Andes. It contains but few animals. Of these there belongs to the

IV. FAMILY PLANTIGRADA, only the bear. This animal, according to Humboldt's picture of the Andes, attains a height of 16,000 feet, which is immediately on the confines of the snow line. The others belong to the

V. FAMILY DIGITIGRADA, among which *Mephitis mapurito* ascends to a height of 9,000 feet. Of the genus Felis, *Felis discolor* (puma) ascends the Cordilleras of Chile to a height of at least 11,000 feet, an elevation which, in that latitude, cannot be much under the limits of snow. In the Andes of Peru, *Felis onça* (the jaguar) scarcely attains a height of 3,000 feet; whilst, in the same region, *Felis pardalis* (the ocelot) ascends to twice that height above the level of the sea, penetrating beyond the region of palms and pisang plants to the uppermost limits of chinconas and tree-ferns.

SECTION II.

HUNTING DISTRICTS OF THE FUR-BEARING ANIMALS, AND THEATRE OF THE WHALE AND SEAL FISHERY[1] IN THE NORTHERN HEMISPHERE

COMPRISING THE FOUR FOLLOWING ORDERS OF MAMMALIA:—

CARNIVORA, RODENTIA, RUMINANTIA, CETACEA.

INTRODUCTION.

The distribution of the fur-bearing animals and the Cetacea forms an appropriate appendix to the Map of the Carnivora, since, although some of the animals treated of occur in each of the above mentioned orders, yet the greater number of their species belong to the Carnivora.

The Carnivora living upon the land, as well as those inhabiting the water, are constantly pursued by man, who finds in their fur-coated skins a material fitted for the immediate purposes of necessary dress, or which may be worked into the most costly articles of luxury and fashion.

In consequence of continual hunting during the last two centuries, the most valuable families have greatly decreased in numbers, and hence the price of furs has risen in an extraordinary degree. When the Cossacks conquered Kamtchatka, at the beginning of the eighteenth century, sables were so plenty that half-a-dozen could be procured in exchange for a knife, and for a hatchet a dozen was reckoned a fair equivalent; and the Kamtchatdales even smiled at strangers who gave such useful articles in return for what appeared to them objects of no value. Their barks were covered with sable skins; and for 10 rubles worth of ironware they obtained, without the slightest trouble, skins to the value of 500 or 600 rubles.

On account of this superfluity, thirty or forty pieces were risked on a game of chance, and it was little thought of whether three or four hundred sables were lost or won. These times of superfluity have long since passed away; at present, a commandant in Kamtchatka is no longer enabled to gain 30,000 rubles a-year, as was formerly the case; and the Kamtchatdales calculated, that, at the middle of the last century, their country did not contain one-fifth of the number of sables that it did at the commencement of it.

Fur-bearing animals inhabit especially the northern portions of the earth. In those latitudes where, from the nature of the climate and soil, little or nothing is to be gained by cultivation, the widely-scattered families of man are compelled to seek the means of subsistence in the produce of the chase, or in fishing; and since the civilized inhabitants of Europe have extended to the east and west, the hunting of wild animals has come to be considered by them as an important article of trade. The people of the cold countries of Upper and Farther Asia have, from time immemorial, known and practised the chase of fur-bearing animals, by which they had to supply the wants of a pressing necessity—that of providing warm clothing for the long and severe winter season. This has always led to an immense consumpt of these animals among the Mantchourian, Mongolian, Northern Chinese, and many Turkish populations.

THE ASIATIC PROVINCE.

The regions occupied by fur-bearing animals naturally form two distinct provinces—that of the Old World, or the Asiatic, and the New World, or the American province.

The Asiatic province comprises the whole of Siberia, with Kamtchatka and the river district of the Amour, or Mantchouria. Towards the south it extends also over the districts of Middle Asia, inhabited by a Turkish population, to the Sea of Aral, and stretches towards the west, over the Uralian Mountains, on the one side to the Black Sea, and on the other to the northern part of the Scandinavian Peninsula, where the chase of these animals is conducted;—in the former, by a Turkish, and in the latter by a Finnish population, who, however, are not subjected to the same necessity in its prosecution as the different natives of Siberia.

Of the order of Carnivora, which in this province are specially sought on account of their fur, the first eight animals are distributed over the whole district, which extends, within the limits of forests, from the western boundaries of the province, through the whole of Siberia, Mantchouria, and Kamtchatka, to Behring Strait and the Pacific Ocean:—

Ursus arctos (the common or brown bear).
Gulo borealis (the common glutton).
Meles Taxus (the common badger).
Mustela putorius (the fitchet, foumart, or pole-cat).
Mustela vulgaris (the weasel).
Mustela erminea (the ermine).
Mustela Zibellina, the sable, which, in common with the ermine, yields the most valuable fur of all the land martens.
Lutra vulgaris (the common otter).
Lutra marina (the sea otter), the fur of which is valued still higher than that of the ermine and sable, and in which a lucrative trade is carried on with China. This otter inhabits the coasts of Behring Island, of Kamtchatka, the Kurilian Islands, and Jesso, as well as the long series of the Fox or Aleutian Isles, and the coasts of Oonalaska, whose wealth this animal constitutes. It is also found along the whole western coast of America to latitude 27° north. To this (the north-west) coast another species, *Lutra phocula*, appears to be limited. The skin of this is as highly valued as that of the first species.

The following three species,
Mustela lutreola (the little fish otter),
Mustela martes (the common marten), and
Mustela foina (the fouine) are only found in the western part of the province, on this side of the Uralian Mountains, from the Crimea and the Caucasus to Finland.
Mustela Sarmatica (Pallas) (the tiger marten), between the Don and the Volga to latitude 53° north, and eastwards in Middle Asia.
This district is also inhabited by
Mygale moschata (the Russian musk shrew-mouse, musk-rat or desman), northwards as far as 57°, but westwards not farther than the Uralian Mountains.
Canis vulpes (the common fox), with its varieties, *Vulpes alopex*, *Vulpes crucigera* (cross), and *Vulpes Nigra* (black fox), is, within the woodlands of the whole Asiatic province, an object of assiduous pursuit; and so also is
Canis lupus (the common wolf), and *Canis lupus lycaon* (the black wolf).
Canis corsac (the yellow fox), inhabits the districts between the Ural and the Irtish Rivers and Lake Baikal, as well as the whole of Middle Asia.
Felis lynx (the European lynx).
Felis cervaria (the deer lynx).
Felis borealis (the polar lynx), the last especially, in the western districts of the province, from the farthest north to Mount Altai and the Baikal Sea.

Of the Rodentia there are caught or hunted:—
Sciurus striatus (the earth or striped squirrel), from the Uralian Mountains to the Sea of Okhotsk and the River Anadir.
Castor fiber (the beaver or castor), on the River Obi and its tributaries. It is seldom found beyond the Yenisei River.
Lepus variabilis borealis (the northern hare), from latitude 50° north, and from the western to the eastern limits of the province, especially on the Yenisei, the Khatanga, and in Kamtchatka.
Lepus Tolai (Gm.), (Siberian hare), especially on the banks of the Baikal Lake.
Lepus hyperboreus (Pallas), (the smaller pipe-hare), in the eastern part of the province, and in the country of the Tschuk-tschi.
Lepus Alpinus (Pallas), (the stone or hay hare).

Of the Ruminantia the following are taken, not for their furs or hides, but on account of their musk, which is secreted in a bladder-formed cavity in the buck:—
Moschus moschiferus, L., (the genuine musk deer), which is hunted throughout the whole of the Chinese and Russian part of the country of the Tunguses, where it is found to latitude 60° north, and west from Lake Baikal to the Altai, but only in the mountainous districts, since it prefers the rugged valleys and pine-clad forests, and does not inhabit the open hill-country.

Beyond the limit of forests, in the northernmost parts of the province, there also occur, among the Land-Carnivora:—
Ursus maritimus (the polar bear), on all the coasts of the Arctic Sea; but he is, neither here nor in the New World, expressly an object of the chase; and
Gulo borealis (the glutton), in the extreme eastern point of the Asiatic continent.
Canis vulpes lagopa (the arctic fox) or isatis, which, however, is not limited to that region of mosses and lichens—the Tundry—but extends southwards in the forest zone to latitude 60°, and in Kamtchatka to the outermost point of the peninsula, whence it finds its way on flakes of ice to the Aleutian Isles.
And among the Ruminantia:—
Cervus tarandus (the rein-deer), is hunted by the Tschuk-tschis for the sake of its skin. It is only found in its wild state within the polar circle.

The following native tribes are occupied with the objects of the chase in the Asiatic province:—

1. The Finns, on both sides of the Uralian Mountains, who hunt the lynx, the fox, the marten, ermine, and squirrel, as well as the bear and wolf—for the capture of the last of which a premium is awarded by the Government of Norway. The European Finns follow the chase only as an occasional occupation.
2 The Turkish tribes to the south of the Uralian Mountains, and eastward to the Rivers Irtish and Altai, hunt the marten, the musk shrew-mouse, the polar lynx, and especially the corsac or yellow fox—the skins of which form so important an article of trade, that from forty to fifty thousand are annually conveyed to Orenburg alone.
3. The Samoides, on the borders of the countries occupied by the Finnish and Turkish tribes; and
4. The Yeniseians, who chase the bear, the wild rein-deer, the wolf, hare, fox, the sable (which occurs but seldom on the River Obi), the striped squirrel, and occasionally the ice-fox and the glutton.
5. The Yakuts, a people of Turkish origin, who hunt the noble sable, especially at Olekminsk and at Aldan; the noble dark-brown fox near Kolima and Saschiwersk; the ermine at Wilni and Kolima; the ice-fox and musk-deer, as well as the bear.
6. The Tunguses, between the Icy Sea on the north, and the Seas of Okhotsk and Japan on the south, who, in the far north, chase the wild rein-deer, the sable, the musk-deer, the squirrel, and the fox. As the people of Siberia pay their imposts to the Russian Government in the skins of the noble species, so the Tunguses or Mantchous offer their tribute in those of the sable.
7. The Aïnos, on the eastern border of Mantchouria and the Island of Tarakai (or Sagalian), who also, like their brethren in Jesso and the Kurilian Islands, appear to take part in the capture of the valuable sea otter. All traffic at the trading stations of Mantchouria is carried on by the exchange of skins for the merchandise of China.
8. The Yukagers, the Koriaks, and the Tschuk-tschis, inhabiting the north-eastern part of the Asiatic continent, as well as the Itelman (or Kamtchatkans), inhabitants of the peninsula of Kamtchatka, hunt the marten, the sable, the ermine, the fish-otter, fox, ice-fox, the bear, the wolf, the glutton, wild rein-deer, and the hare.

The present traffic in furs in the Asiatic province is, if not more important than formerly, at least very considerable, and produces an enormous profit, which has this peculiarity, that the seller as well as the buyer share in it. This is brought about in the following manner: The Tschuk-tschi, for example, the most active trader of these northern regions, does not always procure his goods himself, but purchases them from his countrymen on the other side of Behring Strait; from them he receives for one-half pood[2] of leaf tobacco a parcel of skins, which he sells again to the Russians for two poods of the same. These two poods of tobacco cost the Russian at the most about 160 rubles[3]; for these he obtains a parcel of furs, which he sells again for at least 400 rubles, and so gains 250 per cent.

The trade between the Tschuk-tschi and the Russians is carried on at a great annual fair, which is held at a place called Ostrovnoi, on the Aniuy river, latitude 68° north, longitude 163° 45′ east. One of the most valuable furs is that of the sable, which is only exceeded by the skin of the black fox. The former is sometimes sold for 40, and the latter from 58 to 100 rubles each, even at the place where they are caught.

THE NORTH AMERICAN PROVINCE.

Three natural districts—the Woodlands, the Savannahs or Prairie Lands, and the Barren Grounds of the polar regions—divide this region. The Woodlands occupy the middle space. The Savannahs extend southward through the Valley of the Mississippi-Missouri, and stretch beyond the Rocky Mountains, over the district of the Columbia River, to the Pacific Ocean. The Barren Grounds lie to the north of the forests; they are distinguished by an almost entire absence of vegetation, the rock being only at intervals covered with a thin soil, which is seldom sufficient to support a shrub or stunted tree. Each of these three districts, according to the nature of the nutriment it affords, is characterized by peculiar genera, or at least peculiar species of fur-bearing animals.

The Forest Region has the greatest number. In it there occur of the order of the Carnivora:—
Ursus Americanus (Pallas), (the American black bear).
Procyon lotor (the racoon).
Meles Labradoricus (Sab.), (the Labrador badger).
Mustela Martes, L. (the common or pine marten).
Mustela Canadensis, L. (the pitan or fisher marten).
Mustela erminea, L. Gm. (the ermine)
Mustela vison, L. Gm. (the vison or mink).
Mustela lutra Canadensis (the Canadian otter).
Canis vulpes fulva (American or red fox), with the varieties ***decussata*** and ***argentata***, black and silver fox.
Felis borealis s. *Canadensis* (Geoff.), (the polar lynx).
Felis rufa (the brown lynx).

Of the order of Rodentia, which are sought on account of their furs, the following especially belong to this district:—
Castor Americanus (F. Cuv.), (the American beaver) and
Fiber zibethicus (Cuv.), (the musk rat or musquash); as well as the
Lepus Americanus (Erxl.), (the American hare).

And of the Ruminantia:—
Cervus alces, L. (the moose-deer), and
Cervus tarandus, L. (the rein-deer).
The following belong in common to the Forest Region and the Region of the Barren Grounds:—
Gulo luscus (Sab.) (the wolverine).
Canis lupus Occidentalis (Rich.), (the American wolf).

In the region of the Barren Grounds are found exclusively:—
Ursus arctos (the brown or barren-ground bear).
Ursus maritimus (the polar bear), which frequents the coasts of the continent and islands of the Arctic regions.
Canis vulpes lagopa (the arctic or polar fox), on the continent as well as the islands.
Lepus glacialis, the polar hare, northward to Melville Island.

In the third, or Prairie Region, the following are abundant:—
Ursus ferox (Lew. and Clarke) (the grizzly bear), the most formidable animal of its species, and of the North American continent. It is common on the slopes of the Rocky Mountains, and is distributed also over the eastern savannahs as far as latitude 61° north; and its southern range is probably the northern borders of Mexico. The hunting of this bear is attended with great danger.
Canis lupus (*s. lyciscus*) *latrans* (the prairie wolf), is smaller than *Lupus Occidentalis*. This is found in great numbers in the plains of the Rivers Saskatchewan and the Missouri.
Canis vulpes cinereo-argentata (the grey fox), the smallest of the North American foxes, the fur of which is of little value.
Lepus Virginianus (Haslan),
Cervus strongyloceros, (Shreb.), *Cervus Canadensis*, Gm. (the wapiti), inhabiting the savannahs on both sides of the Rocky Mountains.

Of all these animals the beaver and the bisam-rat are of the greatest importance in the American fur trade. These two species, indeed, form the staple of this trade; for it is calculated that from eighty to ninety thousand beaver skins, and more than half a million musquash skins, are annually imported into Europe alone.

FUR-BEARING ANIMALS IN THE SOUTHERN HEMISPHERE.

There is also a hunting district for fur-bearing animals in the Southern Hemisphere; but, on account of its small extent and limited population, it has not been deemed necessary to insert it on the map. It lies in the temperate region of South America, in Chile, Tucuman, and Buenos Ayres, but chiefly in the river district of La Plata, and on the western side of the Cordilleras, in the Archipelago of Chonos, and is inhabited by *Myopotamus bonariensis* (Commerson), *Hydromys coypus* (Geoff.)—the marsh-beaver, which in Chile is called coypu, and in the pampas quuiya—the beautiful skin of which is known in the fur-trade under the Spanish name of nútria.

THEATRE OF THE CAPTURE OF THE NORTHERN WHALE AND THE SEAL TRIBE.

The voyages of the Dutch and English navigators through the Polar Seas, in search of a north-east or north-west passage to India, were the means of making known the habitat of the *Cetacea*. The companions of Barentz, who in the year 1596 discovered Spitzbergen, and the exploration of Hudson, who soon after attempted the north-west passage, drew the attention of their several countrymen to the vast number of whales which were found in those seas, and opened up an immense field for the activity of their adventurous seamen, and the speculation of their enterprising merchants. Manned by Basque seamen, who ever since the twelfth century had followed with the greatest success the hunting of whales in the higher latitudes of the Atlantic Ocean, the Dutch, the English, Hamburgers, French, and Danish, sent ships to the Greenland Seas, to prosecute a branch of industry which held out such enticing prospects of gain. The Dutch, from their greater activity and industry, soon acquired an advantage over all their competitors. In the latter part of the seventeenth century they carried this trade to the greatest perfection, and there were seasons in which not fewer than 260 ships and 14,000 seamen were employed in it; but, through insatiable avarice, this branch of industry was lost to the Basques in the beginning of the fifteenth, and to the Dutch in the eighteenth century.

The family of the Balæna is either extirpated or so greatly reduced in numbers in the Greenland Seas, that the most experienced seaman can no longer reckon on a profitable produce. He is, therefore, compelled to seek new ground for exertion; and during the last thirty years, since the discoveries of Ross, Parry, Lyon, and others, attention has been turned especially to Baffin Bay, Hudson Bay, and other portions of the Arctic Ocean, where the trade is now chiefly in the hands of the English.

The average quantity of British shipping employed in this trade during the nine years ending in 1818 was,—

From England,	91	132
From Scotland,	41	

The number sent out in 1830 was,—

From England,	41	91
From Scotland,	50	

Showing a decrease in the interval of 40 ships. This decrease is steadily progressing up to the present time. In the year 1830, which was peculiarly disastrous to the whole fishery, 19 British ships were totally wrecked, and 12 seriously injured during the season.

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[1] We use this phrase in compliance with general custom, although it appears as anomalous to apply the term "fishing" to the capture of mammiferous animals as it would be to speak of the "hunting of fishes." The prevalence of this custom has, doubtless, tended to keep alive the vulgar notion that whales are fishes.

[2] A Russian pood is equal to 36 lbs.

[3] A ruble is equal in value to 3s. 1¼d. sterling.

The *Cetacea* (whales), forming the last order of Mammalia, are divided into two great tribes, the *ordinary* and the *herbivorous* Cetacea. The first and most important group, which ranges throughout the depths of ocean, and feeds upon the usual prey of fishes, consists of the two families —*Balænidae* (true whales, rorquals, and blubber whales) and *Physeteridae* (cachalots or spermaceti whales). The second group consists of the third family, *Delphinidae* (narwhals, dolphins, grampuses, porpoises), &c. These, although entirely aquatic, frequent generally the estuaries of rivers, and feed on the vegetable substances which grow on the shores.

Those of the Cetacea which form the immediate subject of inquiry, the habitat of which is chiefly in the seas of the Northern Hemisphere, are the following :—

I. FAMILY BALÆNIDAE.

Balæna mysticetus (common, Greenland, or right whale). In a commercial point of view, this is the most important of all the Cetacea, since it furnishes more oil than any of the others, while, from the slowness of its movement, and its timidity, it affords greater facilities of capture. From the earliest records of whaling, we find that *Balæna mysticetus* was captured in the Atlantic Ocean, as far south as the line marked on the map—"mean equatorial limit of right whale;" and at the beginning of the present century it was found in great numbers at the entrance to Hudson Strait, and on the borders of the ice, near the coast of Labrador. In the year 1817 the whalers proceeded northwards to Lancaster Sound, and occasionally entered Barrow Strait; but this, which was called the south-west fishery, has, in its turn, been abandoned, since, in the language of whalers, it is "fished out." Whales have thus been found gradually to retire more and more to the northward; and they are now found in considerable numbers only to the north of Lancaster Sound. They are still captured, however, in Hudson Bay and Davis Strait; but they are seldom seen in the Greenland Sea, or in the vicinity of Spitzbergen, where they were formerly so numerous.

Balænoptera boops s. Rorqualus borealis (great northern rorqual) is found chiefly along the edge of the ice between Bear or Cherry Island and Novaia Zemlia, as well as in the vicinity of Jan Mayen Island, and towards Spitzbergen, between the parallels of 70° and 76°; it also occurs at the mouth of the Firth of Forth, and when the sea is open, in the summer months, it advances to the northward as far as the 80th parallel.

Balænoptera acuto-rostrata s. Rorqualus minor (lesser rorqual) frequents the rocky bays of Greenland, especially during the summer months. It is also found on the coasts of Iceland and Norway, and sometimes even in lower latitudes—a specimen having been caught near Queensferry, in the Firth of Forth, in 1834. On the Norwegian coasts, from Finnmark down to the lower latitudes of Bergen, a species of whale, *Balæna glacialis*, is occasionally caught. This is sometimes considered as a separate species, sometimes as a young mysticete; but Oken is disposed to consider it rather as a young rorqual. It follows the herring to the innermost recesses of the Scandinavian fiords; as soon as it has entered sufficiently far, the mouth is closed with a strong net, he is then fired at with arrows, and allowed to swim about for five or six days till he dies. The Firth of Forth, on the east coast of Scotland, is remarkable for the number of whales which occasionally visit it.

The Pacific Ocean is also inhabited by a great number of whales, which frequent the coasts of the Russo-American colonies, and the inhabitants of Kodiak and Oonalashka have for many years engaged in their capture. But it is only since 1833 that the Russo-American Company have begun to avail themselves of the European method of capturing the whale, by the use of the harpoon. The inhabitants of the Aleutian Islands distinguish four species of Balæna.

The specific identity of the Balæna of the North Atlantic—the "right whale" of the Greenland and Davis Strait fisheries—with that of the North Pacific, the Okhotsk, and Behring Strait fisheries, is not doubted by practical whalers; and the recent discovery of a north-west passage, or communication between those two oceans, by Captain Maclure, sufficiently warrants this conclusion. The ordinary habitat of the *Balæna mysticetus* is the Polar Ocean, north of latitude 60° north, though occasionally, and at particular seasons, they are found 20° to 30° south of this parallel. Their food consists entirely of the smaller medusæ, which are found existing in great abundance within the polar regions.

In the Antarctic, the "right whale" of the whalers is also found, but the species differs from that of the Arctic Circle. It is the *Balæna Australis* of Desmoulins and Cuvier; in size it is rather smaller than the Balæna of the north, seldom exceeding 50 feet in length. Its colour is uniformly black; and a good-sized whale will produce 80 to 90 barrels of oil.

During the summer of the southern hemisphere, this whale is found approaching to latitude 40° south, and even occasional stragglers somewhat farther. It is, however, sufficiently ascertained that throughout the tropical, and part of the sub-tropical seas, not a single individual of the right whale, either of the northern or southern polar seas, is ever met with, showing that the nature and habits of these animals fit them only for the colder waters of the ocean. The "black fish," a species of *Phocæna*, about 20 feet in length, is also common in the South Seas, and has an extensive range both in the Pacific and Atlantic.

II. FAMILY PHYSETERIDAE.

Physeter macrocephalus (sperm whale, cachalot). This is the largest and most important of the southern whales, and is the only species which becomes the object of capture of the whale-fishers. Others have been distinguished, but, according to Cuvier and the best modern observers, they can only be deemed varieties. Such are the *Physeter catoden* (round-headed or lesser cachalot), *Physalus cylindricus* (cylindrical cachalot), *Physeter microps* (sharp-nosed cachalot). The *Physeter tursio* (high-finned cachalot, with a high dorsal fin, and inhabiting the north seas) is, however, a distinct species. The sperm whale equals in size the *Balæna mysticetus* (the Greenland or right whale). Sixty feet is the average length; the largest authentically recorded is 76 feet in length by 38 in girth. It is the male only that attains this size, the female or cow rarely exceeding 30 to 35 feet in length. From 50 to 100 and 150 barrels of oil are the products of these respective sizes of whales. The head of this whale is enormously large, constituting one-third of the whole body; it is of a square form, the snout being very round and blunt; the body is cylindrical, tapering to the tail; colour of the skin, a dull black. From the posterior third of the back arises a spurious fin or hump, of a pyramidal form. The bones of the head and jaws resemble those of the dolphin; the lower jaw is furnished with teeth; the breathing-hole consists of a single spiracle, placed somewhat to the left side. The food of the cachalot is the cuttle-fish, or "squid" *sepia*, though occasionally portions of bony fishes are found in its stomach. The cavity of the head contains a large quantity of spermaceti, and the other parts of the body sperm oil. Ambergris is found in the intestines, but is only an occasional and rare product, probably arising from disease. The sperm whale is gregarious, and usually forms parties of from 25 to 100 and upwards. These are called "schools" by the whale-fishers. These schools are composed of females or cows, attended by their young, and at least one adult bull of the largest size. The smaller associations, or "pods," consist of young half-grown males.

Notwithstanding its bulk, the cachalot speeds through the ocean with great activity; its usual velocity is at the rate of 8 miles an hour, but when alarmed this is increased to 15 miles. Naturally they are very timid, though individual instances of boldness and courage, when irritated, are not uncommon.

The habitat of the cachalot is properly the central and deeper parts of the ocean, or the vicinity of abrupt coasts, and only occasionally and rarely the shallower seas. Their range includes the whole waters of the tropical and temperate regions, but they do not penetrate to the Polar seas. In the southern seas they extend as high as between the 60th and 70th parallels of latitude, or off the shores of the South Shetland Islands. In the northern seas they do not extend beyond the 60th parallel; for though stragglers have been observed on the south coast of Greenland, and as high as the corresponding latitude off the American and Asiatic continents, the cachalot is unknown to the whaler in the Arctic Ocean. The cachalot has been found in the Mediterranean and in the British seas frequently.

The temperate regions embraced within the 35th parallel of the equator, north and south, are the most usual and most convenient fishing-grounds for the cachalot; and perhaps within this range they are most abundant; but beyond these limits they are also fished for, as off the south-west coast of Chiloe and Gaufor, latitude 44° south; off Chatham Isles, 44° south; and among the Aleutian Islands, North Pacific, in latitude 53° north. Mr F. Bennett judiciously remarks—"Large parties of these whales have been observed to affect particular spots at distant times, though it has not been ascertained that their visits to any one tract of water are sufficiently regular to be considered as periodical; and it should be observed that, when seasons are spoken of in this fishery, the term applies less to the periodic presence of the whales in the regions referred to, than to the convenience of whale-ships in regard to weather and other circumstances. Thus the 'Japan cruise' in the Pacific, extending from 20° to 40° north latitude, commences with the spring months April and May, and concludes with the autumnal months September and October, or when the accession of inclement weather may be expected in that region, although there is no reason to doubt that whales continue in its waters during the entire year. While driven by winter weather from the north, the whaler occupies his time in the more genial climates of South America and the equator, or 'takes the off-shore season.' The same remark applies also to the sperm fishery in the Indian seas, where its seasons are greatly influenced by the variations of the monsoons. Nevertheless, the Society Islanders expect to see the cachalot around their shores only during the months of April and May; and whalers consider that from September to December are the most profitable months for cruising near the equator. Vast tracts of ocean may be cruised over without the slightest trace of the sperm whale being perceived, whilst other, and often very limited extents of water, will exhibit the species in great abundance. Much of this apparent caprice, however, depends upon natural causes. Powerful currents, or the space intervening between two currents setting in opposite directions, are the favourite resorts of this whale, and doubtless where its food is found in greatest abundance amidst the inhabitants of the deep, swept together by these local streams. Hence, wheresoever currents are denoted by the concomitant marine animals—floating shell-fish, with myriads of *medusæ*, forming what sailors term 'thick water'—cachalots may reasonably be expected."[1]

The importance of the sperm-whale fishery will be obvious when we find it stated that no less than 600 ships and 15,000 American seamen are employed in it, exclusive of about 50 British ships, and those of other nations.[2]

III. FAMILY DELPHINIDAE.

The most remarkable among this family is *Narwhalus s. Monodon monoceros* (narwhal, or sea-unicorn). This is regarded by the inhabitants of Greenland as a migrating animal. Its favourite resort appears to be among the ice-fields of the polar regions, and the bays and creeks of the Greenland coast, especially in Disco Bay, Davis Strait, and the shores of Iceland. In these latitudes it is sometimes very abundant; while it is occasionally found wandering, as if out of its element, near the shores of Northern Europe and the British Isles. It is seldom or never found in southern latitudes. Its home seems to be between 70° and 80° of north latitude.

Delphinapterus leucas (beluga or white whale). The chief habitat of this species is in the higher latitudes of the arctic regions. It is abundant in Hudson Bay, Davis Strait, and in some localities on the northern coasts of Asia and America, where it frequents the principal rivers. Steller mentions this species as occurring at Kamtchatka; and, according to Charleroix, it is abundant in the Gulf of St Lawrence, where it follows the tide as far as Quebec. It also abounds near Disco Island, in Greenland, and is frequently found near Spitzbergen; but Mr Scoresby never observed it further to the south than the latitude of Jan Mayen Island; it is also found, however, in the Firth of Forth.

Delphinus globiceps (deductor or ca'ing whale). The chief habitat of this species is between latitude 56° and 60° north; but it is often found in lower latitudes; and in 1832, 98 were captured on the shores of Lewis, one of the Hebrides or Western Islands. It also occurs at the Orkney and Shetland Islands.

Delphinus phocaena (common porpoise). The porpoise occurs in all the seas of Europe; but is most abundant on the western shores of Ireland, which it frequents in innumerable shoals.

Delphinus grampus (the common grampus) is found on the coasts of Greenland, Spitzbergen, and Davis Strait. It also frequently appears in small herds in the seas and firths of the British Islands, probably in all seasons of the year.

SEAL FISHERY.

The most important seal-fishery at present is that which is prosecuted in the seas between Greenland and America by the adventurous seamen of Newfoundland and Nova Scotia, who, early in spring, in the months of March and April, approach the ice-fields, which are floated by the currents from the polar regions, and on which great herds of seals have embarked on a voyage to warmer climates. These fields of ice are called in America sea-meadows. On these, and along the coasts of Labrador, &c., the fishermen of Newfoundland and Nova Scotia annually slaughter more than half a million seals. If to these we add the number caught by the English and Dutch, on the coasts of Greenland and Spitzbergen; by the Russians and Scandinavians on their own coasts; the Russians in Behring Strait, the Sea of Okhotsk, the Caspian, the Aral, and Lake Baikal, &c., we may calculate the entire number of seals annually captured at least at one million.

The seals and morses, as already noticed, form the sixth family of the *Carnivora*, that of *Pinnipedia*. The following are the most important seals belonging to the Northern Hemisphere :—

Phoca vitulina (the common seal) is distributed over all the northern districts, on both sides of the Atlantic Ocean, from the Baltic and North Sea to the Icy Ocean.

Phoca foetida is found also in the northern seas of both hemispheres, from the Baltic to the Arctic Ocean.

Phoca Groenlandica (the harp or Greenland seal), the most prevalent species in the Arctic seas of the New World, is found in winter on the eastern shores as far as latitude 43° north; it occurs also at Kamtchatka, and on Iceland, but is rarely found on the east side of Greenland, or at Spitzbergen.

Phoca barbata (the bearded or great seal) is found in Spitzbergen, and in the whole sealing district of the New World. On the coasts of Kamtchatka it occurs from latitude 56° to 64° north.

Phoca leucopla is most prevalent on the coasts of Iceland.

Phoca lagura is found almost exclusively on the coasts of Newfoundland.

Phoca hispida (the rough or bristled seal) is an inhabitant of the Baltic Sea and the coast of Norway, where it is regularly hunted; it is also found in great numbers in the northern seas of the New World, in Davis Strait, and its vicinity. According to Giesecké, many thousands of this species are killed every year on the west coast of Greenland, about latitude 72° north.

Phoca cristata (the crested seal) appears to inhabit chiefly that part of the Arctic Ocean in the region of Greenland, where it is mostly found in the open sea, and approaches the coast only in the months of April, May, and June. It is abundant in Davis Strait, and on the northern shores of America.

Phoca oceanica (the ocean seal) prefers the colder regions of the ocean, and hence it is only found along the borders of the ice in the White Sea; but, according to the reports of the fishermen, it occurs at all seasons around the shores of Novaia Zemlia.

Phoca leporina (the hare-like seal) frequents also the shores of the White Sea. It is found also on the coasts of Iceland, and within the polar circle at Spitzbergen and Kamtchatka.

Phoca grisea (the grey seal) is common on the northern shores of Europe, and is frequently observed among the Hebrides, the Orkneys, and Shetland Islands.

Phoca ursina (the sea-bear, ursine seal, or fur seal) is at present exclusively confined to the Behring Sea, between Asia and America, where it is captured chiefly around the Commodore and Pribuiloff Islands, and the Island of St Paul. Formerly sea-bears were captured in great numbers in the Gulf of St Francisco; but the seal-hunters of the United States have entirely extirpated them.

Phoca jubata leonina (the lion seal, or sea-lion) occurs in Behring Sea, and on all the islands and coasts of the Pacific Ocean, from latitude 61° north (it is sometimes found, though more rarely, at Stuart Island, latitude 63° 30′ north), southwards to the Kurilian Islands and Jesso; and occasionally at the Ladrones or Mariana Islands, in latitude 15° north. The principal gathering-place of the sea-lion is at the Island of St George, the southernmost of the Pribuiloff Islands, latitude 56° north. None of this species are found in the Sea of Penjinsk, on the west side of Kamtchatka.

The second group of *Pinnipedia*, that of the *morses*, consists of a single genus, and this, again, of a single species, namely :—

Trichechus rosmarus (the walrus), which is usually met with in the seas between Greenland, Spitzbergen, and Novaia Zemlia, in Baffin Bay, from latitude 64° north, in Fox Channel, and in Behring Sea, from the north coasts of Aliaska to the Asiatic coast of Behring Strait. It also occurs at the Magdalene Islands, in the Gulf of St Lawrence, and is seen, though rarely, on the shores of the British Islands. One specimen was killed in the Island of Harris in 1827, and another at the Orkneys in 1825.

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[1] Narrative of a Whaling Voyage, vol. ii.

[2] Maury's Sailing Directions, 1852-3-4.

EXPLANATION OF THE MAP.

The explanatory notes given on the map itself, and the references made to its contents throughout the preceding pages, render any lengthened description of its objects unnecessary. The following additional remarks, however, may be found useful :—

I. In the synoptical tables inserted in the different provinces, on the upper division of the map, the small asterisk (*) indicates, as in the table on page 86 of the text, that the genus before the name of which it is placed belongs exclusively to the province indicated.

II. As in the first Map of Zoological Geography, the limits of distribution of the most important genera and species are defined by lines, and the species belonging to the same genus are uniformly distinguished by the same colours.

III. The typical animals are delineated on the same plan as those in the first map, and show the most characteristic species of all the five families, divided into two groups; namely, those of the Old and those of the New World, with a subdivision of the former, containing all the Carnivora belonging to Great Britain.

All the animals are delineated on the uniform scale of one-thirtieth of nature.

IV. In the lower compartment of the map, the countries in which fur-bearing animals are hunted, are distinguished by colours; and, for want of space, the Latin names of the single species only are given. The southern limits of whales extending beyond the boundaries of the small map, will be found in the large map above.

ZOOLOGICAL GEOGRAPHY.

MAMMIFEROUS ANIMALS: ORDERS RODENTIA AND RUMINANTIA.

SECTION I.—RODENTIA (*GNAWING ANIMALS*). BY GEO. R. WATERHOUSE, ESQ.

It will be perceived, upon inspecting the List of the Species of Rodents, and the tabular arrangement displaying their geographical distribution and classification, that the species of the same group most frequently have a wide range in the same, or nearly the same, parallels of latitude;[1] but when the species are inhabitants of the high ridges of mountains, they will follow the course of the mountains, though that course may be in the opposite, or north and south, direction.[2] Examples will be found of groups which are for the most part confined to the higher latitudes, reappearing again in low latitudes, but at great elevations.[3] It will further be perceived, that the great mass of the South American Rodents belong to a group which is of a lower grade of organization than the mass of the species of the Old World, and northern parts of the New.—Family SCIURIDÆ. All the aberrant forms of the *Sciuridæ* are peculiar to the northern hemisphere, with the exception of one genus, *Pteromys*, of which one or two species extend a little below the equator, being found in Java and Sumatra. But few species of this family (the highest of the Rodentia) are found in South America, and these belong exclusively to the genus *Sciurus;* they are chiefly natives of the northern portions of the continent. Two, or perhaps three, species occur south of the equator, but on the eastern side of the Andes only. In the southern parts of the Eastern Hemisphere the *Sciuridæ* likewise become rare: Java is their most southern limit in the Indian Archipelago; and in Africa, we find only two species extending as far south as the Cape of Good Hope.[4]—Family MURIDÆ. The characters which are most common to the Rodentia, are in this family most evenly balanced, and hence it may be regarded as the typical family of the order. It has the greatest geographical range, and is the only family aberrant forms of which occur in the southern parts of both hemispheres.[5]—Family HYSTRICIDÆ. As the class Mammalia presents an order which is, for the most part, confined to South America—the order *Edentata*—so the order Rodentia possesses a family which is essentially American—the *Hystricidæ*. Out of about eighty-seven species appertaining to this family, seven only are found out of the South American province, and these belong to the most highly organized divisions of the family.[6]—With regard to the zoological provinces, as indicated by the distribution of the Rodentia, I conceive it is desirable to ascertain, as far as possible, the value, or relative importance, of the divisions which may be formed; and that this end may, to a certain extent, be accomplished by considering them in relation to the rank of the groups which mark them out, and to the proportionate number of species and sections which they have in common. Thus Europe, Asia, Africa, America, and Australia, might, in this point of view, be regarded as but one zoological province, and as distinct from the groups of islands comprehended under the head Polynesia, these islands having no representatives of the order Rodentia, at least none but such as there is good reason to believe have been introduced by shipping; whilst the different quarters of the globe included in the first province have each numerous representatives of the group under consideration. This great province, might then (so far as the Rodents are concerned), be regarded as of a rank equal to that of the order Rodentia.—Descending from the order to the families into which it is divided, we should find in Australia a province of inferior rank, but one next in importance, since, whilst each of the other quarters of the globe included in the first province possesses species of *all* the families of the order, in the Australian district the order is represented by species of *one* family only. South America would become a province of the third degree of importance, one equal in rank to a sub-family,[7] being characterized by the possession of several sub-families which are peculiar to it. The north polar regions of both hemispheres would form a province of low rank, characterized by the presence of certain *species* in common. North America, generally, might be linked together with Europe and North Asia, by the presence of numerous genera in common;[8] but the zoological affinity (if I may so speak) of the two hemispheres will be found to decrease in proportion as the parts are more remote from the polar region. By degrees new genera make their appearance, the whole of which are distinct, if those of one hemisphere be compared with those of the other. Although distinct, however, it is interesting to observe, that frequently they present the same kind of modifications—adaptive modifications in distinct types. Thus the genera *Dipodomys* and *Macrocolus* of Mexico (no doubt from the high table-land) are comparable with the gerboas of the central parts of Asia; and the American group, *Geomys*, in like manner, represents the Asiatic section of which *Spalax* may be regarded as the type; whilst far south, where the Hares and Pikas (*Lagomys*) are wanting, we find their analogies in the Cavies and Chinchillas. In about the same parallel of latitude, we find the *Ctenomys* section (the metropolis of which appears to be in Bolivia), and that of *Spalacopus* or *Poephagomys*, of Chili, representing the genera *Georychus* and *Bathyergus* of South Africa. The genus *Pedetes* of the Cape, may, in like manner, be compared with that of *Lagostomus* of Patagonia.[9]

TABLE I.—SHOWING THE DISTRIBUTION OF RODENTIA OVER THE GLOBE

FAMILIES and Genera of RODENTIA, with the Number of their Species.	Europe.								Asia.														Africa.							America.										Australia.		Zool. Prov. of the Map.								
																														North America.					South America.							Temp. Prov.			Tropic Prov.					
	Great Britain.	Scandinavia.	Russia, Poland, and Caucasus.	France.	Germany and Switzerland.	Iberian Peninsula.	Italy, with Isles.	Turkey and Greece.	Siberia.	Tartary.	Mongolia and Mantchouria.	Asia Minor and Syria.	Arabia, Persia, Afghanistan.	China.	Japan.	Hindustan and Ceylon.	Himalayan Countries— (Tibet, Nepaul, Bhotan, Assam.)	Eastern Peninsula.	Sumatra.	Java.	Borneo.	Remainder of Indian Isles.	Barbary.	Egypt.	Nubia, Darfur.	Abyssinia.	Senegambia, Guinea.	Cape Colony and Interior.	Madagascar.	British Amer., Greenland.	United States.	California, Columbia.	Mexico.	Central America, West Indies.	Columbia, Guayana.	Brazil.	Peru, Bolivia, Chile.	La Plata, Paraguay.	Patagonia.	Australia.	Van Diemen's Land.	North America.	Europe.	Asia, without East Indies.	Central and S. America.	Africa.	East Indies.	Australia and Van Diemen's L.	Old World.	New World.
	Number of the Species.																																																	
I. SCIURIDÆ, 153	1	1	11	2	4	1	1	3	9	3	3	3	3	6	3	10	15	19	13	11	11	5	1	.	.	4	12	3	1	15	19	25	8	3	4	5	3	.	.	.	.	49	11	35	11	18	42	.	94	59
1. Sciurus, 91	1	1	2	1	1	1	1	1	1	.	.	1	1	6	1	6	7	17	11	7	10	4	1	.	.	4	10	2	1	4	12	11	5	2	4	5	3	.	.	.	.	24	2	12	11	16	32	.	57	34
2. Pteromys 20	.	.	.	.	.	.	.	.	1	.	.	.	.	.	2	3	6	2	2	4	1	1	.	.	.	.	.	.	.	2	1	2	.	.	.	.	.	.	.	.	.	3	.	9	.	.	9	.	17	3
3. Anomalurus 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2	.
4. Tamias 8	.	.	2	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	4	1	.	.	.	.	.	.	.	.	6	2	1	.	.	.	.	2	6
5. Spermophilus 21	.	.	5	.	1	.	.	1	4	2	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	3	5	2	.	.	.	.	.	.	.	.	11	4	9	.	.	.	.	10	11
6. Arctomys 8	.	.	1	.	1	.	.	.	1	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	2	1	2	.	.	.	.	.	.	.	.	.	3	2	3	.	.	1	.	5	3
7. Aplodontia 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
8. Castor 2	.	.	1	1	1	.	.	1	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	1	1
(SITUATION UNCERTAIN) 16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	4	3	3	2	1	.	.	.	.	.	.	13	.	.	3	.	.	.	.	16
9. Dipodomys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
10. Macrocolus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
11. Heteromys 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2	.	.	.	.	2
12. Saccomys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
13. Perognathus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
14. Geomys 10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	2	1	1	.	.	.	.	.	.	.	9	.	.	1	.	.	.	.	10
II. MURIDÆ, 306	10	13	36	12	15	10	11	9	27	17	4	11	14	3	7	17	8	6	6	6	2	4	13	12	15	13	6	35	2	9	28	5	3	5	2	39	14	17	14	20	6	39	44	61	77	75	27	21	105	114
Sect. 1. Myoxina.																																																		
15. Myoxus 10	1	1	3	3	3	2	2	2	.	.	.	1	.	.	1	.	.	.	.	.	.	.	1	.	1	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	2	.	5	.	.	10	.
16. Graphiurus 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2	.
Sect. 2. Dipodina.																																																		
17. Alactaga 8	.	.	2	.	.	.	.	.	2	4	1	.	2	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	6	.	2	.	.	8	.
18. Dipus 6	.	.	3	.	.	.	.	.	2	3	1	.	1	.	.	.	.	.	.	.	.	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	4	.	2	.	.	6	.
19. Jaculus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
20. Pedetes 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
Sect. 3. Ctenodactylina.																																																		
21. Ctenodactylus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
Sect. 4. Murina.																																																		
22. Sminthus 3	.	1	2	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	3	.
23. Mus 75	5	5	7	5	6	6	6	5	6	3	2	5	3	2	6	10	4	2	5	5	2	3	5	5	7	8	3	13	2	2	9	2	2	4	2	2	2	2	2	15	5	9	7	15	4	26	14	16	66	11
24. Mus (Isomys, Sundev.) 2	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	2	.
25. Mus (Akomys, I. Geoff.) 3	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	3	.
26. Mus (Golunda, Gray) 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.
27. Mus (Vandeleuria, G.) 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	1	.
28. Mus (Nesokia, Gray) 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	2	.	3	.
29. Dendromys 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2	.
30. Pithechir 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.
31. Cricetomys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
32. Hapalotis 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	4	4	.
33. Phlœomys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.
34. Gerbillus 24	.	.	3	.	.	.	.	.	.	1	.	1	5	.	.	3	.	.	.	.	.	.	2	3	4	1	1	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	7	.	14	3	.	24	.
35. Psammomys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
36. Malacothrix 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2	.
37. Euryotis 5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	5	.
38. Mystromys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
39. Hydromys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	1	1	.
40. Cricetus 8	.	.	5	.	1	.	.	.	4	2	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	6	.	.	.	.	8	.
41. Hesperomys 46	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	24	10	4	9	.	.	1	.	.	45	.	.	.	.	46
42. S. American Muridae 18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	.	7	.	.	.	.	.	.	18	.	.	.	.	18
43. H. (Oxymycterus, W.) 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	2	.	.	2	.	.	.	.	2
44. Hesp. (Calomys, Wat.) 5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	1	.	.	.	.	.	3	.	.	.	.	5
45. Akodon 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
46. Drymomys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
47. Reithrodon 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	3	.	.	.	.	3
48. Neotoma 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2
49. Sigmodon 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2
Sect. 5. Spalacina.																																																		
50. Rhizomys 6	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	4	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	4	.	6	.
51. Tachyoryctes 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
52. Heterocephalus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
53. Ellobius 2	.	.	1	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	.	2	.
54. Ommatostergus 1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.
55. Spalax 1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.
56. Siphneus 1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.
Sect. 6. Arvicolina.																																																		
57. Arvicola 36	4	5	5	4	5	2	3	2	7	1	.	1	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	2	14	1	.	.	.	.	.	.	.	.	.	19	11	9	.	.	.	.	17	19
58. Lemmus 5	.	1	3	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	2	5	2	.	.	.	.	4	2
59. Fiber 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
Sect. 7. Bathyergina.																																																		
60. Georychus 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2	.
61. Bathyergus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
III. HYSTRICIDÆ, 99	.	.	.	.	.	1	1	1	.	.	.	.	1	.	.	1	.	.	2	1	1	.	1	.	1	.	2	2	.	1	2	1	1	8	12	50	29	13	6	.	.	3	1	1	76	4	3	.	6	77
Sect. 1. Hystricina.																																																		
62. Hystrix 4	.	.	.	.	.	1	1	1	.	.	.	.	1	.	.	1	.	.	1	1	1	.	1	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	2	.	2	.
63. Atherura 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	2	.
Sect. 2. Cercolabina.																																																		
64. Erethizon 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
65. Chætomys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
66. Cercolabes 9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	8	1	1	.	.	.	1	.	.	8	.	.	.	.	8
Sect. 3. Dasyproctina.																																																		
67. Dasyprocta 9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	2	4	5	2	1	.	.	.	1	.	.	9	.	.	.	.	10
68. Cœlogenys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	2	1	.	.	.	.	.	.	1	.	.	.	.	1
Sect. 4. Echimyina.																																																		
69. Aulacodus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
70. Loncheres 14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	8	.	.	.	.	.	.	.	.	11	.	.	.	.	11
71. Isothrix 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	4	.	.	.	.	4
72. Echimys 7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5	1	2	.	.	.	.	.	.	6	.	.	.	.	6
73. Dactylomys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	2	.	.	.	.	2
74. Nelomys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
75. Cercomys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
76. Petromys 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
77. Capromys 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	2
78. Plagiodontia 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
79. Myopotamus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	1	.	.	.	.	1
Sect. 5. Octodontina.																																																		
80. Octodon 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	3	.	.	.	.	3
81. Schizodon 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
82. Spalacopus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
83. Ctenomys 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	2	1	.	.	.	.	.	5	.	.	.	.	5
84. Habrocoma 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2	.	.	.	.	2
Sect. 6. Chinchillina.																																																		
85. Chinchilla 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	1	.	.	.	.	1
86. Lagidium 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	2	.	.	.	.	2
87. Lagostomus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
Sect. 7. Caviina.																																																		
88. Cerodon 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
89. Dolichotis 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	1	.	.	.	.	1
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91. Hydrochœrus 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	2	.	.	.	.	.	.	1	.	.	.	.	1
IV. LEPORIDÆ, 46	4	2	4	2	3	2	3	1	6	1	2	1	3	1	1	3	6	.	.	1	.	.	1	2	2	1	.	4	.	5	7	8	2	.	.	1	1	1	.	.	.	14	5	16	1	7	4	.	30	16
92. Lepus 37	4	2	3	2	3	2	3	1	2	.	1	1	2	.	1	3	3	.	.	1	.	.	1	2	2	1	.	4	.	4	7	8	2	.	.	1	1	1	.	.	.	13	5	8	1	7	4	.	22	15
93. Lagomys 9	.	.	1	.	.	.	.	.	4	1	1	.	1	1	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	8	.	.	.	.	8	1
AMOUNT OF SPECIES, 604	15	16	51	16	22	14	16	14	42	20	8	15	21	10	11	31	29	25	21	19	14	9	16	14	18	18	20	13	3	32	60	41	17	17	19	95	47	31	18	20	6	118	61	113	166	104	76	21	325	282

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[1] Amongst other examples, the species of the genera *Pteromys*, *Spermophilus*, *Tamias*, *Arctomys*, *Arvicola* and *Lagomys* may be mentioned.

[2] *Arctomys Himalayanus*, and species of the genera *Arvicola* and *Lagomys* occur on the Himalayan Mountains.

[3] *Lagomys princeps* has a range of 30 degrees of latitude; the Chinchillas likewise have a very extended range in the north and south directions.

[4] These two species are members of the genus *Sciurus*, and are possibly identical with species found in Abyssinia.

[5] *Reithrodon* and *Hesperomys* may be noticed as examples of aberrant forms of the family *Muridæ*, which occur in the Western Hemisphere—even down to the Strait of Magalhaens. In the Eastern Hemisphere occur the genera *Hydromys* and *Hapalotis* of Australia; and those of *Graphiurus*, *Pedetes*, *Dendromys*, *Gerbillus*, *Malacothrix*, *Euryotis*, *Mystromys*, *Georychus*, and *Bathyergus*, of South Africa.

[6] It will be perceived that the species of the more highly organized divisions of the *Hystricidæ* (viz. *Hystricina*, *Dasyproctina*, and *Echimyina*) increase in number towards the tropical or northern parts of South America; and that in the more southern parts the less organized divisions almost exclusively occur. The most typical group of the Rodents has the greatest geographical range, and the most highly organized species of the different families have the next most extended range. Rodents increase in number towards the tropical portions of the globe.

[7] Marked as "Sections" of Families on the List, &c.

[8] The presence of numerous species of *Spermophilus*, the genus *Lagomys*, and the increased number of species of *Tamias* and *Arctomys*, on the western side of North America, link that part more nearly to the temperate and northern Europeo-Asiatic provinces than other parts of North America.

[9] The *Aulacodus* of Senegambia resembles, to a very considerable extent, the *Capromys* of Cuba; and *Petromys* of South Africa represents the Octodons of Chili; but in these two cases there exists a tolerably close affinity between the animals of the opposite hemispheres.

TABLE II.—LIST OF THE RODENTIA, WITH THEIR GEOGRAPHICAL DISTRIBUTION.

I. FAMILY.—SCIURIDÆ (SQUIRREL FAMILY.)

			Geographical Distribution.
A.—European and North Asiatic Species.			
GENUS SCIURUS.			
vulgaris,	L.	Common Squirrel,	Europe, Northern Asia, and Japan.
anomalus,	Güld.	Georgian	Georgia, subalpine beech and oak forests of Mount Caucasus.
Syriacus,	Ehrenb.	Syrian	Syria and Arabia.
B.—African Species.			
Stangeri,	Wat.	Stanger's Squirrel	Fernando Po.
rufobrachiatus,	•	Red-armed	•
erythrogenys,	•	Red-cheeked	•
pyrrhopus,	F. Cuv.	Red-footed	Fernando Po and Ashanti.
Cepapi,	Smith	Cepapi	South Africa.
multicolor,	Rüppell	Many-coloured Sq.	Abyssinia.
annulatus,	Desm.	Ringed-tailed	Gambia and Senegal districts, and Abyssinia.
punctatus,	Temm.	Freckled	Ashanti.
Poensis,	Smith	Fernando Po	Fernando Po.
nasutus,	Temm.		Ashanti.
Congicus,	Kuhl	Congo	Congo.
getulus,	L.	Barbary	Barbary, Marocco.
albovittatus,	Desm.	White Striped Ground Sq.	Gambia, Senegal, and Abyssinia.
Namaquensis,	Licht.	South African Ground	South Africa.
rutilus,	Rüppell		Abyssinia.
Madagascariensis,	Shaw	Madagascar	Madagascar.
C.—Indian Species.			
Indicus,	Erxl.	Bombay, or Malabar Sq.	Nearly throughout Hindoostan, from Travancore in the South up to Bengal.
bicolor,	Sparrm.	Bicoloured	Java, Sumatra, Malacca, Siam, Assam, and Nepaul.
ephippium,	Müller		Borneo.
Leschenaultii,	Desm.		Java, Sumatra, Singapore.
aureiventer,	Is. Geoff.		Sumatra, Siam.
macrourus,	Pennant	Ceylon	Ceylon.
Keraudrenii,	Lesson		Birman Empire.
hippurus,	Is. Geoff.		Java, Sumatra, Borneo, Malacca, Assam, Bhotan.
rufo-niger,	Gray		China.
castaneoventris,	•		•
Prevostii,	Desm.		Borneo, Malay Peninsula, Siam, China.
vittatus,	Raffles		Sumatra, Borneo, Malacca, Canton.
Plantani,	Ljung		Java, Sumatra.
nigro-vittatus,	Is. Geoff.		Java, Sumatra, Borneo, Canton.
Finlaysoni,	Horsf.		Siam, and Sichang Island in the Gulf of Siam.
laticaudatus,	Müller		Borneo.
Philippinensis,	Wat.		Mindanao (Philippine Islands).
pygerythrus,	Is. Geoff.		Pegu.
affinis,	Raff.		Singapore, the Island of Pulo Penang in the Strait of Malacca
caniceps,	Gray		Bhotan, Northern India.
bimaculatus,	Temm.		Malacca.
cinnamomeus,	•		•
Lokriah,	Hodgs.		Nepaul, Sikim, Assam.
Lokrioides.	•		Nepaul, Assam.
Chinensis,	Gray		China.
flavimanus,	Is. Geoff.		Cochin-China.
insignis,	F. Cuv.		Java, Sumatra, Borneo.
tristriatus,	Waterh.		Forests of the Ghauts.
palmarum,	Linn.		Deccan, Calcutta.
sublineatus,	Waterh.		Madras, Nilgherries.
M'Clellandii,	Horsfd.		Assam and Bhotan.
tenuis,	•		Singapore.
modestus,	Müller		Sumatra, Borneo, Malacca.
melanotis,	•		Java, Sumatra, Borneo.
exilis,	•		Sumatra, Borneo, Malacca.
rubriventer,	•		Celebes.
leucomus,	Forster		•
murinus,	•		•
D.—North and Central American Species.			
capistratus,	Bosc.	Fox Squirrel,	Middle and southern parts of the United States. A variety of this species is found in Texas and Mexico.
subauratus,	Bachm.	Golden-bellied Squirrel,	New Orleans and Mexico.
cinereus,	Gmel.	Cat	Middle and northern parts of the United States.
leucotis,	Gapper	White-eared Grey	From the middle portions of the United States to Hudson's Bay.
Carolinensis,	Gmel.	Carolina Grey	From the Peninsula of East Florida westwards into Louisiana, and in the northern direction, extending into North Carolina.
niger,	Linn.	Black	States of New York and Pennsylvania, and extends into Upper Canada.
Audubonii	Bachm.	Larger Louisiana Black Sq.	Louisiana.
fuliginosus,	•	Lesser •	Louisiana, along the banks of the Mississippi.
Hudsonius,	Pall.	The Chickaree	From the arctic extremity of the woods, southwards to the 40th parallel of latitude—rare below that parallel.
Richardsonii,	Bachm.	Columbia Pine Squirrel	Frequents the pine forests of the Rocky Mountains, west of the great chain.
lanuginosus,	•	Downy	North-west coast near Sitka, and at Puget's Sound.
Lewisii,	Smith		From the Missouri.
Clarkii,	H. Smith		Missouri.
aureogaster,	F. Cuv.	Californian	California and Mexico.
Douglasii,	Gray	Douglas'	Columbia and California.
Colliei,	Richards.	Collie's	California.
nigrescens,	Bennett	Dusky	•
Bottæ,	Lesson		•
mustelinus,	Bachm.		•
leporinus,	•		North America.
occidentalis,	•		•
mollipilosus,	•		North California.
Boothiæ,	Gray		Honduras.
Richardsonii,	•		•
variegatoides,	Ogilby		North-west coast of South America—Mexico?
E.—South American Species.			
Langsdorffii,	Brandt		Brazil and Guayana.
variabilis,	Is. Geoff.		Peru and Bolivia.
æstuans,	Linn.	Brazilian Squirrel	Guayana, Brazil, Peru, and Bolivia.
stramineus,	Gervais		Peru.
pusillus,	Geoff.		Cayenne.
igniventris,	Wagner		Brazil.
pyrrhonotus,	•		•
gilvigularis,	•		North-west portions of Brazil.
GENUS PTEROMYS.			
leucogenys,	Temm.	Japan Flying	Japan.
nitidus,	Desm.		Java, Sumatra, Borneo, Malacca, Siam.
petaurista,	Pall.		From Bengal southwards to Travancore.
Oral,	Tickell		Tenasserim, Midnapour, Chyebassa.
magnificus,	Hodgs.		Nepaul, chiefly the central and northern hilly districts.
nobilis,	Gray		Nepaul (lower, central, and northern hilly districts), and Dargulling
inornatus,	Is. Geoff.		From Cashmere.
elegans,	Müller		Java, and in the Island of Nusa-Kambang, near Java.
albiventer,	Gray	White-bellied Flying Sq.	Nepaul.
caniceps,	•		Dargulling.
fimbriatus,	•		Nepaul.
alboniger,	Hodgs.		Nepaul, Dargulling.
Horsfieldii,	Waterh.		I. of Banka?
sagitta,	Desm.		Java, Sumatra.
genibarbis	Horsf.		Java.
Momoga,	Temm.		Japan.
volans,	Linn.		Siberia.
volucella,	•		Canada and the United States.
sabrinus,	Rich.		Forests of Canada, the Rocky Mountains, and the fur countries up to the 57th parallel.
Oregonensis,	Bachm.		From the pine woods on Columbia River.
GENUS ANOMALURUS,	Waterh.		
Fraseri,	•	Fraser's Anomalurus,	Fernando Po and Sierra Leone.
Pelii,	Temm.		Ashanti.
GENUS TAMIAS.			
striatus,	Linn.	Black-striped Tamias,	On the Oural Mountains, and throughout the wooded portions of Siberia, as far as the Sea of Okhotsk, and the Anadyr.
Uthensis,	Pallas		From the region of the River Uth (Russia.)
quadrivittatus,	Rich.	Four-striped	Fur countries of North America, and extends southwards along the eastern declivity of the Rocky Mountains to the sources of the Platte and Arkansas.
Lysteri,	•	Lyster's	Ranges on the eastern side of the Rocky Mountains, from the 50th parallel down to the Carolinas.
tenebrosus,	Bachm.		North America.
Hindei,	Gray		California.
Townsendii,	Bachm.	Townsend's	Common in woods on the west coast of North America.
minimus,	•		Plentiful along the banks of the Rio Colorado.
GENUS SPERMOPHILUS.			
fulvus,	Licht.	Fulvous Spermophilus,	On the banks of the southern portions of the River Oural, extending northwards to about the 50th degree
mugosaricus,	Licht.		Found between the Caspian Sea and Lake Aral, on the banks of the River Oural, and westwards as far as Sarepta on the Volga.
brevicaudatus,	Brandt.	Short-tailed	From the Altai.
undulatus,	Eversm.	Wave-marked	On the River Oural; extends from about the 50th to the 56th degree of north latitude. Common at Orenbourg.
musicus,	Ménétr.		On the Caucasus Mountains, extending nearly up to the snow line.
Eversmanni,	Brandt.	Eversmann's	From the Altai.
Citillus,	Linn.		Found in Austria; extends northwards into Silesia, and eastwards through temperate Europe, and into Siberia.
erythrogenys,	Brandt	Red-cheeked	Altai Mountains, and mountains of Balkash.
concolor,	Is. Geoff.		Persia, particularly in the great plain of Sultania.
xanthoprymnus,	Bennett	Erzeroum	Erzeroum.
Richardsonii,	Sabine	Richardson's	Prairies of the Saskatchewan.
Franklinii,	•	Franklin's	•
Hoodii,	•	Hood's	Prairies, and ranging southwards to Mexico?
Mexicanus,	Licht.	Mexican	Mexico and California.
Douglasii,	Rich.	Douglas'	Banks of the Columbia.
Beecheyi,	•	Beechey's	Upper California.
macrourus,	Bennett	Long-tailed	California.
Parryi,	Rich.	Parry's	From the arctic coasts and Rocky Mountains, down to the 58th parallel.
annulatus,	Aud. et B.	Ring-tailed	Western prairies.
lateralis,	Say	Flank-striped	Eastern declivity of the Rocky Mountains, from the 57th degree down to the sources of the Arkansas.
Townsendii,	Bachm.	Townsend's	Inhabits the prairies on the Wallawalla (Columbia River).
GENUS ARCTOMYS.			
Marmotta,	Linn.	Alpine Marmot,	From the Alps.
Bobac,	Schreb.	Bobac	In Poland, Russia, Siberia.
Himalayanus,	Hodgs.	Nepaul	Northern hilly region of Nepaul, and in Tibet.
Thibetanus,	•	Tibet	Tibet. Perhaps the same as *A. Bobac.*
caudatus,		Long-tailed	From the Valley of Gombur—Cashmere.
Empetra,	Schreb.	Quebec	Frequents the woods of Canada, and the fur countries up to the 60th parallel.
pruinosus,	Gmel.	Hoary	Rocky Mountains.
flaviventer,	Bachm.	Yellow-bellied Marmot,	From the mountains between Texas and California.
GENUS APLODONTIA,	Rich.		
leporina,	•	The Sewellel,	New Caledonia, and the banks of the Columbia River.
GENUS CASTOR.			
Fiber,	Linn.	European Beaver,	In the rivers of temperate and northern Europe and Asia, between the 30th and 67th degrees of latitude.
Canadensis,	Kuhl	North American Beaver,	Ranges on the eastern side of the continent of North America, from the most northern woods down to the confluence of the Ohio, with Mississippi. Found likewise on the western side of the continent.
FAMILY ———— ?[1]			
GENUS DIPODOMYS,	Gray		
Phillipii,	•		Mexico.
GENUS MACROCOLUS.	Wagner		
halticus,	•		Mexico.
GENUS HETEROMYS,	Desm.		
Thompsoni,	•		Trinidad.
Desmarestii,	Gray		Coban, Central America.
GENUS SACCOMYS,	F. Cuv.		
anthophilus,	•		North America.
GENUS PEROGNATHUS,	Neuw.		
fasciatus,	•		North America, on the banks of the Upper Missouri, where it unites with the Yellow-stone River; occurs also in the neighbourhood of the Mandans villages.
GENUS GEOMYS,	Rafin.		
Townsendii,	Bach.		Plains of the Saskatchewan.
Douglasii,	Rich.		Plains of the Columbia, and California?
bulbivorus,	•		•
bursarius,	Shaw		Canada.
pinetus,	Rafin.		Georgia.
talpoides,	Rich.		Florida.
umbrinus,	•		Louisiana.
Mexicanus,	Licht.		Mexico.
Quachil,	Gray		Coban (Central America.)
rufescens,	Neuw.		North America; numerous in the prairies of the Upper Mississippi, as far as the Rocky Mountains.

II. FAMILY.—MURIDÆ (RAT FAMILY.)

			Geographical Distribution.
SECT. 1. MYOXINA.			
GENUS MYOXUS.			
avellanarius,	Linn.	Common Dormouse,	In the southern and western parts of temperate Europe.
elegans,	Temm.	Japan	Japan.
Orobinus,	Wagner		From Sennaar.
quercinus,	Linn.		In France, the western parts of Germany and Switzerland, and likewise in North Africa, viz., in Tunis and Marocco.
melanurus,	Wagner	Black-Tailed	Sinai.
Dryas,	Schreb.		Southern districts of the Volga, in Georgia, and in Hungary.
Glis,	•		In southern and temperate parts of Europe, up to the Volga, and into Georgia.
cineraceus,	Rüppell	Ash-coloured	Port Natal, South Africa.
murinus,	Desm.	Cape	Cape of Good Hope.
Coupei,	F. Cuv.	Senegal	Senegal.
GENUS GRAPHIURUS.			
Capensis,	•	Cape Graphiurus	South Africa.
elegans,	Ogilby	Elegant	South Africa, west coast.
SECT. 2. DIPODINA.			
GENUS ALACTAGA.			
Jaculus,	Pall.		Occurs in Europe in the Steppes between the Danube and the Don, and extends down into the Crimea; ranges eastwards to Barnaul on the River Obi, and in the south-east direction into Great Tartary—if Brandt be correct in regarding the *D. decumanus* and *D. spiculum* of Lichtenstein, as well as the *D. vexillarius* of Eversmann, as specifically identical with the *Mus Jaculus* of Pallas.
subacutus,	Wagner		West coast of Arabia.
halticus,	Illiger		In the Steppes of Mongolia.
Acontion,	Pall.		From the Steppes between the Danube and Don, and extends through Great Tartary into Afghanistan.
Elater,	Licht.		In the Kirghis Steppes.
platyurus,	•		On the east shore of the Sea of Aral, near the River Kowan.
arundinis,	F. Cuv.		Barbary.
tetradactylus,	Licht.		Egypt, between Alexandria and Sywah.
GENUS DIPUS.			
Sagitta,	Pall.		Between the Don and the Volga, in the southern steppes of the banks of the Irtish, and extends through Soongaria into Mongolia.
Ægyptius,	Hasselq.	Egyptian Gerboa	North Africa.
hirtipes,	Licht.		On the Upper Nile, from Syene to Dongola, on the west coast of Arabia; and likewise in Tripoli.
macrotarsus,	Wagner		Arabia Petræa.
Telum,	Licht.		In the Kirghis Steppes north of the Sea of Aral, on the east shores of the Caspian; also in the vicinity of Sarepta, on the River Volga.
lagopus,	•		In Bokhara, near the Sea of Aral.
GENUS JACULUS.			
Labradorius,	Davies	Labrador Jumping Mouse	North America, from the 50th parallel southwards, into the United States.
GENUS PEDETES.			
Cafer,	Pall.		South Africa.
S. 3. CTENODACTYLINA.			
GENUS CTENODACTYLUS,	Gray		
Massoni,	•		North Africa (Tunis and Tripoli).
SECT. 4. MURINA.			
GENUS SMINTHUS.			
betulinus,	Pall.		Between the Oural Mountains and the Jenesei; and there appears to be good reason to believe that a small rodent found in Sweden is identical with the present species.
Nordmanni,	Keys. et B.		In the Crimea.
vagus,	Pall.		Found in Northern Asia between the Rivers Obi and Jenesei, ascending as high as latitude 57°, and descends into Tartary.
GENUS MUS.	Linn.		
A.—European and N. Asiatic Species.			
decumanus,	Pall.	Common Brown Rat	Found in all parts of the world.
Rattus,	Linn.	Black Rat	Found throughout Europe, excepting in the extreme north, and, like the Common Brown Rat, has been conveyed to various parts of the globe. It is, however, less frequently met with than that animal.
Alexandrinus,	Is. Geoff.		Tunis, Egypt, Nubia, Italy, and Spain.
Caraco,	Pall.		Eastern Siberia.
sylvaticus,	Linn.	Field Mouse	Throughout Europe, and in western Siberia.
musculus,	•		Found in all parts of the world.
agrarius,	Pall.		From the Rhine, through Germany, into Western Siberia.
hortulanus,	Nordm.		Botanic Garden at Odessa.
minutus,	Pall.	Harvest Mouse	Throughout the whole of temperate Europe, and in the temperate parts of Siberia.
latipes,	Bennett		Trebizond.
Abbottii,	Waterh.		•
B. Indian Species.			
giganteus,	Hardw.		Continental India, Java, and Sumatra.
Perchal,	Shaw		India.
Indicus,	Is. Geoff.		Continental India, Java, Sumatra, Celebes, Java.
decumanoides,	Hodgs.		Northern and central hilly portions of Nepaul.
pictoris,	•		•
speciosus,	Temm.		Japan.
leucogaster,	•		Java.
lepturus,	Müller		Sumatra.
flavescens,	Elliot		Mahratta country.
Booduga,	Gray		•
Meltada,	•		•
platythrix,	Bennett		Deccan—Mahratta country.
Leggada,	Gray		Mahratta country.
striatus,	Linn.		India.
argenteus,	Temm.		Japan.
Tanezumi,	•		•
mollissimus,	•		•
prætextus,	Licht.		Arabia and Syria.
C. African Species.			
pumilio,	Sparrm.		South Africa.
vittatus,	Wagner		
dorsalis,	Smith		•
Barbarus,	Linn.	Barbary Mouse,	North Africa—Algiers.
imberbis,	Rüppell		Province of Samen—Abyssinia.
Dembeensis,	•		On the banks of the Dembea Lake, Abyssinia.
leucosternum,	•		In houses of Massowah, on the coast of Abyssinia.
albipes,	•		Common house-rat at Massowah, Abyssinia.
Abyssinicus,	•		Province of Samen, Abyssinia.
Alleni,	Waterh.		Fernando Po.
Hayi,	•		Marocco.
fuscirostris,	Wagner		Sennaar.
limbatus.	•		•
orientalis,	Rüppell		Throughout the north-eastern portions of Africa (Egypt, Nubia, and the coast of the Red Sea).
gentilis,	Licht.		Egypt and Nubia.
dolichurus,	Smuts.		Cape of Good Hope.
colonus,	Brants.		South Africa (Algoa Bay).
Verreauxii,	Smith		South Africa, near Cape Town.
Natalensis,	•		South Africa, in the neighbourhood of Port Natal.
muscardinus,	Wagner		Caffraria.
silaceus,	•		Cape of Good Hope.
modestus,	•		•
minutoides,	Smith		South Africa—Cafferland.
D. North American Species.			
Leconteii,	Aud. et B.		North America.
Michiganensis,	•		•
Carolinensis,	•		•
humilis,	Bachm.		•
palustris,	Harlan		New Jersey and South Carolina.
polionotus,	Wagner		Georgia.
Americanus	Dekay.		New York.
E. Central American Species.			
Tequina,	Gray		Coban. These two species perhaps do not belong to the genus *Mus.*
Tasmacus,	•		•
F. Australian Species.			
Australis,	Gray		Liverpool plains.
setiger,	•		Van Diemen's Land.
albocinereus,	Gould		Moore's River—interior of Western Australia.
fuscipes,	Waterh.		King George's Sound, Bass' Straits, and Van Diemen's Land.
lutreola,	Gray		New South Wales, Mosquito Islands, and Van Diemen's Land.
Gouldii,	Waterh.		New South Wales, South Australia.
Adelaidensis,	Gray		South Australia.
Greyi,	•		•
delicatulus,	Gould		Port Essington.
hirsutus,	•		•
Novæ-Hollandiæ,	Wat.		New South Wales.
penicillatus,	Gould		Port Essington.
lineolatus,	•		Darling Downs.
gracilicaudatus,	•		• (Oakley Creek.)
G. MUS (ISOMYS, SUNDEV.)			
testicularis,	Sundev.		Bahr el Abiad.
Niloticus	Is. Geoff.		Nubia, Abyssinia, and Arabia.
G. MUS (AKOMYS, I. GEOF.)			
Cahirinus,	Is. Geoff.		Egypt.
dimidiatus,	Cretzch.		•
russatus,	Wagner		Sinai.
G. MUS (GOLUNDA, GRAY)			
Ellioti,	Gray		Mahratta Country.
G. MUS (VANDELEURIA, G.)			
oleraceus,	Bennett.		Deccan, Madras, and Nepaul.
G. MUS (NESOKIA, GRAY)			
Hardwickii,	Gray		India.
Kok,	•		Mahratta Country.
hydrophilus,	Hodgs.		Northern and central hilly districts of Nepaul.
GENUS DENDROMYS.	Smith		
mesomelas,	Licht.		South Africa.
melanotis,	Smith		•
GENUS PITHECHEIR,	F. Cuv.		
melanurus,	•		Java and Sumatra.
GENUS CRICETOMYS,	Waterh.		
Gambianus,	•		Gambia district, Western Africa, and Fernando Po.
GENUS HAPALOTIS,	Licht.		
albipes,	•	White-footed Hapalotis,	New South Wales, Western Australia and South Australia.
longicaudatus,	Gould	Long-tailed	Western Australia—neighbourhood of Moore's River.
murinus,	•	Murine	New South Wales.
Mitchellii,	Ogilby	Mitchell's	South Australia, and Western Australia, in the neighbourhood of Moore's River.
GENUS PHLŒOMYS,	Waterh.		
Cumingii,	•	Cuming's Phlœomys,	Island of Luzon (Philippines).
GENUS GERBILLUS.			
Indicus,	Hardw.	Indian Gerbillus,	Found almost throughout Hindoostan, extending from Bengal, southwards to Travancore.
Cuvieri,	Waterh.	Cuvier's	Madras.
otarius,	F. Cuv.		India.
erythrourus,	Gray		Afghanistan.
afer,	•		South Africa—vicinity of Cape Town.
montanus,	Smith		South Africa, near the sources of the Orange River.
pygargus,	F. Cuv.		Senegal.
Libycus,	Licht.		North Africa—Egypt and Arabia Petræa.
Burtoni,	F. Cuv.		Darfour.
pyramidum,	Is. Geoff.		Egypt.
tenuis,	Smith		South Africa—to the north of Latakoo.
auricularis,	•		South Africa, western districts, principally north of the Orange River.
Ægyptius,	Desm.		Tunis, Tripoli, Egypt, and Nubia.
tæniurus,	Wagner		Syria.
crassus,	Sundev.		Arabia Petræa.
venustus,	•		Bahr el Abiad.
murinus,	•		•
myosurus,	Wagner		Syria.
longicaudus,	•		West coast of Arabia.
Shawii,	Duvern.		Algiers (and Tunis?)
pallidus,	Wagner		South-east portions of Russia.
tamaricinus,	Pall.		Vicinity of the Caspian Sea.
meridianus,	•		•
lacernatus,	Wagner		Abyssinia.
GENUS PSAMMOMYS.			
obesus,	Rüppell		Egypt, Alexandria, and Tunis.
GENUS MALACOTHRIX.			
albicaudata,	Smith		South Africa—at Graham's Town, and north of the Orange River.
typica,	•		South Africa, district of Graaf, Reynet.
GENUS EURYOTIS.			
irrorata,	Licht.		South Africa, near Cape Town.
Brantsii,	Smith		Interior districts of South Africa—common in certain parts towards the mouth of the Orange River.
pallida,	Wagner		South Africa.
rufifrons,	Rüppell		•
unisulcata,	F. Cuv.		Central and eastern districts of the Cape Colony.

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[1] The six genera provisionally placed here are but imperfectly known; the species they contain all possess large cheek-pouches, and are provided with $\frac{4}{4}$ molar teeth, unless the *Dipodomys Phillipii* should furnish an exception in the dental formula; they have a form of muzzle which approximates them to certain shrews.

LIST OF THE RODENTIA, WITH THEIR GEOGRAPHICAL DISTRIBUTION.

(TABLE II.—*continued.*)

			Geographical Distribution.
GENUS MYSTROMYS,			
albipes,	Wagner,		South Africa.
GENUS HYDROMYS,			
australis (chrysogaster & leucogaster of authors.)			New South Wales, Western Australia, South Australia, and Van Diemen's Land.
GENUS CRICETUS,	F. Cuv.		
frumentarius,	Pall.	The Hamster,	In Germany, and the eastern portions of temperate Europe, to the Caucasus; in the west of Siberia to the Obi, north to lat. 60°.
arenarius,	"		In the Crimea, and in the neighbourhood of the Volga, the Oural and Irtish rivers.
nigricans,	Brandt		In the Caucasus.
auratus,	Waterh.	Golden Hamster,	Aleppo.
Accedula,	Pall.		On the Oural and Volga rivers, and extends into Armenia, being found at Erzeroum.
phaeus,	"		From the Steppes of the Volga, and from the neighbourhood of the Caspian Sea; found also in Persia.
Songarus,	"		On the Irtish River, Siberia.
furunculus,	"		On the Obi, and in Dauria.
GENUS HESPEROMYS,	Waterh.	New World Rats.	
pilorides,	Desm.		Martinique.
Brasiliensis,	Is. Geoff.		Bahia, Bahia Blanca, and Bolivia.
physodes,	Licht.		Brazil, Province of San Paulo.
vulpinus,	"		Near the Uruguay.
Angouya,	Pictet		Bahia, Brazil.
leucogaster,	Brandt		Brazil.
pyrrhorhinus,	Neuw.		"
orobinus,	Wagner		"
aëreus,	"		Brazil, at Rio Francisco.
dasytrichos,	Neuw.		"
subflavus,	Wagner		"
arvicoloides,	Pictet		Bahia, Brazil.
nigrita,	Licht.		Rio de Janeiro.
Boliviensis,	Waterh.		Bolivia.
tumidus,	"		Maldonado, La Plata.
obscurus,	"		"
arenicola,	"		"
gracilipes,	"		Bahia Blanca.
rupestris,	Gervais		Bolivia.
melanostoma,	Tschudi		Peru.
leucodactylus,	"		"
xanthopygus,	Waterh.		Santa Cruz, and Port Desire, Patagonia.
griseo-flavus,	"		Rio Negro.
micropus,	"		Santa Cruz.
canescens,	"		Port Desire.
xanthorhinus	"		Santa Cruz, and Hardy Peninsula, Tierra del Fuego.
Magellanicus,	Bennett		Port Famine, Strait of Magalhaens.
longicaudatus,	"		Chile; abundant in the wooded country south of Conception, and in the Valley of Quillota.
brachiotis,	Waterh.		On a small island in Midship Bay, Chonos Archipelago.
longipilis,	"		Chile, in the provinces of Aconcagua, Valparaiso, and Colchagua.
Darwinii,	"		Chile, Coquimbo.
Renggeri,	"		Valparaiso.
megalonyx,	"		Chile, near the Lake of Quintero.
sabellinus,	Wagner		Brazil.
auritus,	Licht.		Bahia, Rio Janeiro—and Paraguay?
cinnamomeus,	Pictet		Bahia, Brazil.
maculipes,	"		"
caniventris,	Wagner		Brazil,
leucogaster,	"		"
concolor,	"		"
fuliginosus (Natt.)	"		From Ipanema, Brazil.
pygmaeus "	"		"
brachyurus "	"		From Itarare, Brazil.
aliurus "	"		"
leucodactylus "	"		From Rio Parana, Brazil.
[illegible] "	"		From Labrador.
South American Muridæ, which have been described as members of the Genus Mus, but which require further examination.[1]			
longitarsus,	Rengger		Paraguay.
callosus,	"		"
rufus,	Desm.		"
cephalotes,	"		"
Laucha,	"		"
nigripes,	"		"
tomentosus,	Licht.		Woody parts of Uruguay.
squamipes,	"		Brazil.
leptosoma,	"		Bahia, Brazil.
aquaticus,	Lund		Brazil
mastacalis,	"		"
vulpinus,	"		"
longicaudus,	"		"
laticeps,	"		"
expulsus,	"		"
lasiotis,	"		"
principalis,	"		"
lasiurus,[2]	"		"
GENUS HESPEROMYS (Oxymycterus),	Waterh.		
nasutus,	"		Maldonado, La Plata.
rostellatus,	Wagner		Bahia, Brazil.
GENUS HESPEROMYS (Calomys),	Waterh.		
elegans,	"		Bahia Blanca.
bimaculatus,	"		Maldonado, La Plata.
flavescens,	"		Maldonado, La Plata, and Bahia, Brazil.
leucopus,	Raf.		North America.
aureolus,	Bachm.		"
GENUS AKODON,	Meyen		
Boliviense,	"		Peru.
GENUS DRYMOMYS,	Tschudi		
parvulus,	"		"
GENUS REITHRODON,	Waterh.		
cuniculoides,	"		St. Cruz, St. Julian, and Port Desire, Patagonia.
typicus,	"		Maldonado, La Plata.
chinchilloides,	"		Southern shore of the S. of Magalhaens, near the eastern entrance.
GENUS NEOTOMA,	Say et Ord		
Floridana,	"	Florida Rat,	Florida.
Drummondii,		Rocky Mountain Neotoma,	Rocky Mountains, Columbia, and California.
GENUS SIGMODON,	Say et Ord		
hispidum,	"	Rough-haired Sigmodon,	Florida.
ferrugineum,	Harlan	Rufous,	Cotton fields on the Mississippi. (This is probably identical with the preceding species.)
SECT. 5. SPALACINA.			
GENUS RHIZOMYS,	Gray		
sumatrensis,	"	Bamboo Rat,	Malacca.
sinensis,	"	Chinese Bamboo Rat,	China.
badius,	Hodgs.		Lower and central hilly districts of Nepaul, Dargilling and Siam.
castaneus,	Blyth		From Arracan, Birmah.
[illegible]	M'Clelland		Tenasserim.
macrocephalus,	Rüppell		Shoa, Abyssinia.
GENUS TACHYORYCTES,	Wagner		
splendens,	Rüppell		Abyssinia, in the vicinity of Gondar.
G. HETEROCEPHALUS,	"		
glaber,	"		Shoa, Abyssinia.
GENUS ELLOBIUS,	G. Fisch.		
talpinus,	Pall.		Temperate Russia, and the west of Siberia, extending N. to lat. 55°.
GENUS OMMATOSTERGUS,	Nordm.		
Pallasii,	K. et Blas.		Found in the Government of Ekaterinoslav, S. Russia, and extends eastwards into the Caucasus, and westwards into Hungary.
GENUS SPALAX,	Pall.		
Typhlus,	"	Mole Rat,	S. Russia, from the Volga to the Polish portions; found also in Hungary.
GENUS SIPHNEUS,	Brants		
Aspalax,	Pall.	The Zokor,	Altai Mountains, not extending northwards beyond the 58th lat.
SECT. 6. ARVICOLINA.			
GENUS ARVICOLA,	Lacép.		
amphibius,	Linn.	Water Vole, or Water Rat of England,	Found throughout Europe, and in Siberia, extending eastwards as far as the River Lena, and northwards to the Arctic Ocean.
terrestris,	"		Switzerland, in Alsace, and likewise on the Bavarian Alps, ascending to a considerable height.
ratticeps,	Keys. et B.		Russia at Veliki Ustjug (government of Wologda).
nivalis,	Martins	Com. Field Vole of Eng.	Snowy regions of the Alps.
arvalis,	Pall.		Throughout Europe, and in Siberia.
agrestis,	Linn.		Sweden.
neglectus,	Thomps.		Scotland (probably the same as the *A. agrestis* of Linnæus).
Savii,	De Selys Longch.		Italy.
glareolus,	Schreb.	The Bank Vole of Eng.	Occurs in France, Belgium, Holland, Germany, Denmark, and Sweden.
rutilus,	Pall.		Sweden, Finland, N. Russia and Siberia, and extends into Kamtschatka and the neighbouring islands.
œconomus,	"	Economic Vole,	Siberia.
saxatilis,	"		Siberia, the alpine portions.
alliarius,	"		Diffused throughout Siberia.
socialis,	"		Found in the neighbourhood of the Caspian Sea, and extends into Persia and South Russia.
gregalis,	"		Eastern Siberia.
Syriacus,	Licht.		Syria.
Roylei,	Gray		Cashmere.
North American Species.			
xanthognathus,	Leach	Yellow-nosed Vole,	Hudson's Bay.
Pennsylvanicus,	Richards	Wilson's Vole,	United States.
riparius,	Ord		"
noveboracensis,	Rafinesq.		"
borealis,	Richards		"
rubricatus,	"		Behring Strait.
ochrogaster,	Wagner		North America.
pinetorum,	Le Conte		Pine forests of Georgia.
Gapperi,			South Carolina.
Sayi,	Bachm.		
Townsendii,	"		
Oregoni,	"		Columbia River.
Labradorius,	"		
scalopsoides,	Aud. et B.		Long Island, vicinity of New York.
fulvus,	"		Western States.
nasutus,	"		Near Boston, at the Falls of Niagara, and N. parts of New York.
Oneida,	De Kay		Common in the western parts of the State of New York.
rufescens,	"		Neighbourhood of Oneida Lake, and in Hamilton and St. Lawrence counties.
leucogaster,	Pr. v. N.		
GENUS LEMMUS,			
Norvegicus,	Desm.	Norway Lemming,	Sweden and Norway.
torquatus,	Pall.		Polar regions of both hemispheres.
Obensis,	Brants		North Asia, and northern parts of N. America.
lagurus,	Pall.		On the Oural River, in the Steppes of Great Tartary, and extending beyond the Irtish.
albigularis,	Wagner		Sitka, Russian America.
GENUS FIBER,	F. Cuv.		
zibethicus,	Linn.	Musquash, or Musk Rat,	North America, from the Arctic Sea, nearly to the Gulf of Mexico.
S. 7. BATHYERGINA.			
GENUS GEORYCHUS,	Illiger		
Capensis,	Pall.	Bless-Mole, or Sand Rat,	Cape of Good Hope.
cæcutiens,	Licht.		"
GENUS BATHYERGUS,	Desm.		
maritimus,	Gml.	Coast Rat,	South America.
III. FAMILY—HYSTRICIDÆ.			
SECT. 1. HYSTRICINA.			
GENUS HYSTRIX,	Linn.		
cristata,	"	Crested, or Common Porcupine	Italy (in the Apennines), Sicily, Spain, North Africa, and Cape of Good Hope.
hirsutirostris,	Brandt	Indian Porcupine	Continental India.
Hodgsoni,	Gray	Nepal Porcupine	Nepal.
Javanica,	F. Cuv.	Java Porcupine	Java, Sumatra, and Borneo.
GENUS ATHERURA,	F. Cuv.		
fasciculata,	Shaw	Indian Brush-tailed Porc.	Siam and the Malay Peninsula.
macroura,	Linn.		Sumatra?
Africana,	Gray	African Brush-tailed Porc.	West coast of Africa, (Sierra Leone, and Fernando Po).
SECT. 2. CERCOLABINA.			
GENUS ERETHIZON,	F. Cuv.		
dorsatus,	Linn.	Canada Porcupine	North America, between the 37th and 67th parallels.
epixanthus,	Brandt		California, Unalaschka, and Sitka.
GENUS CHÆTOMYS,	Gray		
subspinosus,	Licht.		Brazil.
GENUS CERCOLABES,	Brandt		
prehensilis,	Linn.	Brazilian Tree Porcupine	Guiana, Brazil, and Bolivia.
platycentrotus,	Brandt		——— ?
nycthemera,	Licht.		Brazil.
bicolor,	Tschudi		Peru (east side of the Andes).
spinosus,	F. Cuv.		Brazil.
Novæ-hispaniæ,	Briss.		East coast of Mexico.
melanurus,	Wagner		Surinam, and northern parts of Brazil.
villosus,	F. Cuv.		Brazil.
pallidus,	Waterh.		West Indies?
S. 3. DASYPROCTINA.			
GENUS DASYPROCTA,	Illiger		
Aguti,	Linn.	The Agouti,	North and east parts of Brazil.
cristata,	Desm.		Surinam.
Azaræ,	Licht.		Paraguay, Bolivia, and the southern parts of Brazil.
croconota,	Wagler		Brazil, in the region of the Amazon River.
prymnolopha,	"		Guiana.
fuliginosa,	"		Northern provinces of Brazil, and near Borba, in Brazil, and in the region of the Rio Negro above the Cocos.
albida,	Gray		St Vincents, West Indies.
Acouchy,	Erxl.	The Acouchi,	Guiana.
leptura,	Wagner		On the Rio Negro, one of the principal N. tributaries of the Amazon.
Caraliensis,	F. Cuv.		
GENUS CŒLOGENYS,	"		
Paca,	Schreb.	Spotted Cavy, or Paca,	Throughout the whole of South America, on the eastern side of the Andes, down to Paraguay.
SECT. 4. ECHIMYINA.			
GENUS AULACODUS,	Temm.		
Swinderianus,	"	Sierra Leone Ground Rat,	Sierra Leone and Gambia districts.
GENUS CARTERODON,			
sulcidens,	Lund		Minas Geraes, Brazil (with the molars nearly like those of *Echimys*, in this genus the incisors are very broad and grooved, and the skull is very short).
GENUS NELOMYS,	Jourdan		
cristata,	Is. Geoff.		Surinam—Cayenne.
paleacea,	Licht.		Para, Brazil.
Blainvillii,	Jourdan		Bahia, Brazil, from a small island off the coast.
armatus,	Is. Geoff.		Cayenne.
grandis (Natt.)	Wagner		Brazil.
obscurus,	"		"
semivillosus,	Is. Geoff.		Carthagena.
antricola,	Lund.		Interior of Brazil.
unicolor,	Rüppell		Brazil.
macroura (Natt.)	Wagner		
nigrispina (Natt.)	"		
GENUS ISOTHRIX,	Wagner		
picta,	Pictet		Bahia, Brazil.
bistriata (Natt.)	Wagner		From Rio Guapore, Brazil.
pachyura (Natt.)	"		Brazil.
Pagurus, "	"		From Borba, Brazil.
GENUS ECHIMYS,	Is. Geoff.		
Cayennensis,	"	Cayenne Spiny Rat,	Cayenne, Peru, and Brazil.
hispidus,	Desm.		Bahia, Brazil.
albispinus,	Is. Geoff.	White-spined "	"
fuliginosus,	Wagner	Sooty Spiny "	Brazil.
spinosus,	Desm.		Paraguay.
inermis,	Pictet		Bahia, Brazil.
GENUS DACTYLOMYS,	Is. Geoff.		
typus,	"		Probably Brazil.
amblyonyx (Natt.)	Wagner		From Ipanema, Brazil.
GENUS MESOMYS,	"		
ecaudatus (Natt.)	"		From Borba, Brazil.
GENUS CERCOMYS,	F. Cuv.		
cunicularis,	"		Brazil.
GENUS PETROMYS,	Smith		
typicus,	"		S. Africa—found on the rocky hills which occur towards the mouth of the Orange River.
GENUS CAPROMYS,	Desm.		
Fournieri,	"	Fournier's Capromys,	Cuba.
prehensilis,	Poeppig	Prehensile-tailed "	"
GENUS PLAGIODONTIA,	F. Cuv.		
ædium,	"		Saint Domingo, West Indies.
GENUS MYOPOTAMUS,	Is. Geoff.		
Coypus,	Molina	The Coypu,	South America.[3]
SECT. 5. OCTODONTINA.			
GENUS OCTODON,	Bennett		
Degus,	Molina	Cuming's Octodon,	Central provinces of Chile—extends as far north as 28°, and in the southern direction to 35° lat.
Bridgesii,	Waterh.	Bridges' "	
gliroides,	Gerv. & D'Orb.		In the Bolivian Andes, at La Paz.
GENUS SCHIZODON,	Waterh.		
fuscus,	"		Found in the Valle de las Cuevas, on the eastern side of the Andes.
GENUS SPALACOPUS,	Wagler.		
Poeppigii,	"		Chile.
GENUS CTENOMYS,	De Blain.		
Brasiliensis,	"		Brazil, Bolivia, Paraguay, Maldonado, La Plata.
leucodon,	Waterh.		Bolivia, from the Puna, between Cochabamba and La Paz.
Boliviensis,	"		In the warm plains of Santa Cruz de la Sierra, Bolivia.
Magellanicus,	Bennett		Straits of Magalhaens—Port Gregory.
torquatus,	Licht.		
GENUS HABROCOMA,	Waterh.		
Bennettii,	"		Chile, near Aconcagua.
Cuvieri,	"		Chile, Valparaiso.
S. 6. CHINCHILLINA.			
GENUS CHINCHILLA,	Licht.		
lanigera,	Molina	The Chinchilla,	Found on the mountains of Peru, Bolivia, and Chile, occurring on both sides of the Andes; in height it ranges between 12,000 and 14,000 feet. The best skins come from the Argentine provinces and the desert of Atacama.
brevicaudata,	Waterh.	Short-tailed Chinchilla,	Peru.
GENUS LAGIDIUM,	Meyen		
Peruanum,	"		On the Andes of Peru, Bolivia, and Chile.
pallipes,	Bennett		On the Andes of Peru and Bolivia.
GENUS LAGOSTOMUS,	Brookes		
trichodactylus,	"	The Viscacha or Bizcacha,	La Plata—according to Azara, it is not found north of the 30th parallel, and its southern limit is in the neighbourhood of the Rio Negro.
SECT. 7. CAVIINA.			
GENUS CERODON,	F. Cuv.		
rupestris,	Pr. v. N.		Brazil.
GENUS DOLICHOTIS,	Desm.		
Patagonica,	Shaw	Patagonian Cavy,	Patagonia.[4]
GENUS CAVIA,	Klein		
Aperea,	Erxl.	Common Guinea Pig,	South America.
flavidens,	Brandt	Yellow-toothed Guinea P.	Brazil.
leucopyga,	"	White-rumped "	"
Cutleri,	Bennett	Cutler's "	Peru.
fulgida,	Wagler		Brazil, in the Amazon district.
Spixii,	"		Brazil, in the region of the Amazon.
nigricans,	Wagner		"
Kingii,	Bennett		Common at intervals along the coast of Patagonia, from the Rio Negro (lat. 41°) to the Strait of Magalhaens; it is found likewise nearly throughout Bolivia, but always here on very elevated land, occurring at heights of from 10,000 to 12,000 feet.
GENUS HYDROCHŒRUS,	Brisson		
Capibara,	Erxl.	The Capibara,	Inhabits South America, extending from Guiana in the north, to the Rio de la Plata in the south; is met with in Peru and Bolivia, but not found on the west side of the Andes.
IV. FAMILY—LEPORIDÆ (HARE FAMILY).			
GENUS LEPUS,	Linn.		
timidus,	"	Common Hare	Inhabits Europe, extending eastwards apparently almost to the Oural Mountains.
variabilis,	Pall.	The Variable Hare	Inhabits the Eastern Hemisphere, from the 55th parallel northwards beyond the arctic circle; found in the Alps.
canescens,	Nilsson	Ashy-grey Hare	Scandinavia.
hybridus,	Desm.		Russia, between the 55th and 63d degrees of north latitude.
Mediterraneus,	Wagner		Sardinia.
cuniculus,	Linn.	The Common Rabbit	S. and W. parts of Europe, and the greater part of Germany.
Tolai,	Pall.	The Tolai Hare	Hilly situations in Dauria and Mongolia.
Tibetanus,	Waterh.	The Tibet "	Tibet, central and eastern portion.
macrotis,	Hodgs.	Large-eared "	Gangetic plains and Sub-Himalaya.
nigricollis,	F. Cuv.	Black-necked "	India, Madras, Deccan, Java, and the Mauritius.
ruficaudatus,	Is. Geoff.	Red-Tailed "	Bengal.
hispidus,	Pearson		Inhabits Assam, especially in the northern parts of the valley along the base of the Bhotan Mountains.
Sinensis,	Gray	Chinese "	China.
brachyurus,	Temm.	Japan "	Japan.
Ægyptius,	Is. Geoff.	Egyptian "	Egypt.
isabellinus,	Chretz.	Isabelline "	North Africa, Nubia.
Sinaiticus,	Hemp. and Ehr.	Sinai "	Sinai.
Syriacus,		Syrian "	Syria.
Habessinicus,	"	Abyssinian "	On the coast of Abyssinia, and in Nubia?
Arabicus,	"	Arabian "	Deserts of Arabia, near Gonfodah, and in Arabia Felix at Loheia.
saxatilis,	F. Cuv.	Long-eared Cape "	Cape of Good Hope.
Capensis,	Schreb.	Common Cape "	" "
crassicaudatus,	Is. Geoff.	Thick-tailed "	" "
arenarius,	"	Sand "	" "
American Species.			
glacialis	Leach	Polar "	Found throughout Polar America—extends into Russian America in the west, and occurs in Newfoundland and in the State of Maine in the south-east.
Americanus,	Erxl.	American "	Found in the highest mountains of North Virginia; occurs likewise in the States of Massachusetts, New York, Maine, Pennsylvania, and extends northwards to the 64th parallel.
aquaticus,	Bachm.	Swamp "	Found in the western part of the State of Alabama, in the State of Mississippi, the lower part of Louisiana, and extends into Texas.
campestris,	Bachm.		Inhabits the prairies on the Wallawalla, west of the Rocky Mountains, and on the River Platte, on the east side of the mountains (41° 7′ north lat., 17° 45′ east long.)
Bachmani,	Waterh.	Bachman's "	California.
callotis,	Wagler		From Mexico, and the part of California which adjoins.
Californicus,	Gray.	Californian "	California.
Texianus,	Audub. & Bachm.	Texian "	Texas.
Townsendii,	Bachm.	Townsend's	On the plains westward of the Rocky Mountains on the Wallawalla.
longicaudatus,	"		Texas.
Richardsonii,	"		California.
Artemesia,	"		On the plains of the Wallawalla, west of the Rocky Mountains.
aquaticus,	"	Marsh "	Alabama, Mississippi.
palustris,	"		Carolina, Georgia, Florida.
sylvaticus,	"		United States, and southern parts of Canada.
Nuttallii,	"	Nuttall's "	On the banks of several streams which empty themselves into the Columbia, and west of the Rocky Mountains.
Brasiliensis,	Linn.	Brazilian "	Found throughout Brazil, and occurs likewise in Peru, Bolivia, and Paraguay.
GENUS LAGOMYS,	Cuv.		
pusillus,	Pall.	Pigmy Lagomys	Southern districts of the Volga; the southern portion of the Oural chain, and in Southern Siberia, extending to the River Obi.
alpinus,	"	Alpine "	Siberia from the Irtish eastwards into Kamtschatka.
Ogotona,	"	Ogotona "	Sub-alpine districts beyond the Baikal, as well as of the Daurian and the Mongolian desert as far as China.
Roylii,	Ogilby.	Royal's "	Himalaya—from the Choor Mountains.
rufescens,	Gray.	Rufous "	Cabul.
Nipalensis,	Hodgs.	Nepaul "	Nepaul, northern hilly districts, and Tibet?
Hodgsoni,	Blyth.	Hodgson's "	Himalaya—common at Lahore, Ladakh, and Kooloo.
princeps,	Rich.	Little Chief Hare	Rocky Mountains between the 42d and 60th parallels.
hyperboreus,	Pall.	Polar Lagomys	North-east portion of Siberia.

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[1] Besides the above species, some other small Rodents, inhabitants of Brazil, have been associated with the *Arvicolæ*, but without sufficient examination; indeed, we know not yet that they even belong to the section *Muridæ*.

[2] No doubt most of the above eighteen species will require to be located in the genus *Hesperomys*.

[3] Mr Darwin states that "on the east side of the South American continent, the Coypu ranges from lat. 34 deg. to Rio Chupat in 43 deg. 20 min., a distance of 1100 miles. . . . . On the west coast it is found from the valleys of Central Chile (lat. 33 deg.) to 48 deg. south, or perhaps even farther, but not in Tierra del Fuego. So that on the Atlantic side of the continent, the plains of Patagonia check its range southwards; as on the Pacific side the deserts of Chile do to the north." I may notice that the animal occurs in Peru and Bolivia; is said to be rare in Paraguay, and was not met with by Pr. von Neuwied, on the east coast of Brazil.

[4] Mr Darwin states that "near the coast of the Atlantic, the northern limit of the Patagonian Cavy is formed by the Sierra Tapalguen in lat. 37 deg. 30 min., where the plains rather suddenly become greener and more humid. The limit certainly depends upon this change, since near Mendoza (33 deg. 30 min.), where the country is very sterile, the animal again occurs. . . . Its limit southwards is between Port Desire and Port Julian."

SECTION II.

RUMINANTIA (*RUMINATING ANIMALS*).

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

The order Ruminantia is distinguished from all the other orders of Mammalia, by the existence of four stomachs, arranged for the act of ruminating or chewing the cud. These animals are essentially herbivorous, and are all possessed of the cloven hoof; and it is only among them that species are met with whose foreheads are armed with horns. This order, which is one of the most natural and best defined of all the primary groups into which the Mammalia have been divided, is principally represented by the ox, the sheep, the goat, and the deer; but it is usual also to classify with them the giraffe, camels, antelopes, llamas, &c. They are subdivided into 9 genera, comprising in all 180 species, forming about one-eighth of all Mammalia. Following the general law of distribution, the Ruminantia are most numerous in equatorial regions, but, as if created expressly for the use of the human family, they are distributed over all latitudes, in the northern hemisphere at least, from the equator to the regions within the arctic circle; so that, wherever man is found, he is accompanied by those animals most necessary for the supply of his wants and comforts, and most conducive to his progress in arts and civilization. From them he derives a considerable portion of his food and clothing, whether in a savage or a civilized state of society. Their milk, their flesh, their wool, hides, horns, and hoofs, are all converted to his uses; whilst from many of them he derives the most valuable assistance in the labours of the field, and in the transport of commodities. Thus the rein-deer, as is well known, forms the chief comfort, and the principal means of subsistence to the Laplander; and the yak or kash-gow, confers similar benefits on the inhabitants of Tibet and Pamir. Other cattle require the provident care of man to subsist them through the winter, but the kash-gow is left entirely to itself. If the snow on the elevated flats lies too deep for him to crop the herbage, he rolls himself down the slopes, and eats his way up again. The strong, wiry, and pliant hair of its tail is made into ropes, which for strength do not yield to those manufactured from hemp; and the hair of its body is woven into mats. The milk of the yak is richer than that of the common cow.[1] In tropical countries, again, the camel affords to the inhabitants the means of traversing the wide and trackless desert. From this general distribution of the valuable order of animals under consideration we must except the continent of Australia; among the peculiar fauna of that country, as well as in Madagascar, New Guinea, and the greatest number of the South Sea islands, no species of this order has yet been discovered.[2]

DIVISION AND INTENSITY OF THE SPECIES.

Asia and Africa contain by far the greatest number of species of the Ruminantia, the former possessing 96 and the latter 50 of all species, and they form the chief habitat of the numerous genera of Cervus and Antilope, which together comprise more than the half of all Ruminantia. Hence it is not surprising that the Old World, as a whole, should possess such a vast preponderance in species over the New World,—this difference, as shown in the last two columns of the following table, being nearly seven to one; for while the Old World has 162, the New World has only 24 species. From this table also it will be seen, that the genera Camelus, Camelopardalis, and Moschus are almost entirely peculiar to the Old World, that Auchenia is entirely confined to the countries of South America, and that the genus Cervus is the most widely distributed of all:—

TABLE SHOWING THE DIVISION OF RUMINANTIA OVER THE GLOBE.

GENERA, WITH THE Number of their Species.	EUROPE.								ASIA.															AFRICA.						AMERICA.							ZOOL. PROV. OF THE MAP.							
																														N. America.				S. Amer.			Temp. Prov.			Tropic. Prov.				
	Iceland and Scandinavia.	Great Britain.	Russia and Poland.	France.	Germany, Switzerland, and Austria.	Iberian Penins. (Spain, &c.)	Italy and Mediterranean Islands.	Turkey and Greece.	Siberia.	Mongolia, Mantchouria, and Japan.	Asia Minor, Syria, Caucasus.	Persia.	Tartary.	Tibet.	Nepaul, Assam, and Himalaya.	China.	Arabia.	Hindostan and Ceylon.	Eastern Peninsula.	Sumatra.	Java.	Borneo.	Celebes, Moluccas, and Philippine Islands.	Barbary.	Egypt.	Nubia.	Abyssinia.	Senegambia and Guinea.	Cape Colony and Interior.	British America.	United States.	Mexico and California.	Central America and West Indies.	Guayana, Brazil, and Paraguay.	Remainder of South America.	OCEANIA.—Mariana Islands.	North America.	Europe.	Asia (without the East Indies.)	Central and South America.	Africa.	East Indies.	OLD WORLD.	NEW WORLD.
	Number of the Species.																																											
1. Camelus (Camels) . . 2	.	.	1	.	.	.	.	1	1	1	1	2	1	1	1	1	2	2	.	.	.	.	.	1	2	1	1	.	.	.	.	.	.	.	.	.	.	2	2	.	2	2	8	.
2. Auchenia (Llamas) . 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	.	.	3	.	.	.	3
3. Moschus (Musk Deers) 7	.	.	.	.	.	.	.	.	1	.	.	.	1	1	1	1	.	2	.	2	3	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	1	.	2	5	7	.
4. Cervus (Deers) . . . 51	4	3	4	3	4	3	3	3	5	.	2	3	5	1	5	3	.	10	1	2	2	3	4	1	.	.	1	.	.	6	5	2	2	6	3	1	6	5	10	8	1	21	37	14
5. Camelopardalis (Giraffes) 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	2	.	2	.
6. Antilope (Antelopes) 48	.	.	1	1	2	1	.	1	1	2	2	1	1	.	3	.	1	3	.	1	.	.	.	3	1	3	4	9	20	1	1	1	.	.	.	.	1	2	5	.	34	6	47	1
7. Capra (Goats) . . 20	.	.	.	.	1	1	1	.	1	.	4	2	3	2	4	1	2	1	.	.	.	.	.	.	1	1	1	1	.	.	.	1	.	1	.	.	1	2	8	1	4	4	18	2
8. Ovis (Sheep) . . . 27	.	.	.	.	1	3	2	2	2	1	6	8	6	1	5	.	1	1	.	.	.	.	.	1	2	1	1	1	.	1	2	.	.	.	.	.	2	4	13	.	3	5	25	2
9. Bos (Oxen) 20	.	.	1	.	1	1	1	1	.	.	1	1	.	1	4	3	.	6	3	1	2	2	3	.	1	1	1	.	1	2	2	1	.	.	.	.	2	2	6	.	2	8	18	2
AMOUNT OF SPECIES 180	4	3	7	4	9	9	7	8	11	4	16	17	17	7	23	9	6	25	4	6	7	6	7	6	7	8	10	13	22	10	10	5	2	7	5	1	12	17	45	12	50	51	162	24

DISTRIBUTION OF GENERA AND SPECIES.

1. *Camelus* (Camels). The Arabian camel (Djemal of the Arabs), from which the dromedary is only distinguished by higher breeding and finer qualities—both being possessed of only one hump—is a native of Asia, where, from the earliest ages to the present day, it has formed the chief means of communication between the different regions of the East. Its present geographical distribution extends over Arabia, Syria, Asia Minor, to the foot of the Caucasian chain, the south of Tartary, and part of India. In Africa, it is found in the countries extending from the Mediterranean to the Senegal, and from Egypt and Abyssinia to Algiers and Marocco. It is also very abundant in the Canary Islands.

Arabia produces the greatest number of these valuable animals, the province of Nejed being, on this account, entitled *Om el Bel*—the mother of camels; and the camel of Oman is celebrated for its fleetness and beauty. After the conquest of Granada, the Arabian camel was introduced into Spain by the Moors, and at that time it was abundant in the southern provinces, but as a species it is now extinct. The only place in Europe where this camel is now reared is at Pisa, where it was probably introduced during the sixteenth century, and where, in the arid plains of San Rossora, the country bears a faint resemblance to the desert regions of Asia and Africa.

The Bactrian camel (*Camelus Bactrianus*), is distinguished from the former by having two humps on its back, by its hair being more rough and shaggy, and by being stronger and more muscular; it is the camel of Central Asia, being most abundant in the countries to the north of the Taurus and the Himalayan Mountains. It is also found in the Crimea and the other countries bordering on the Caucasian Mountains; but, although it is said by Pallas to occur in a wild state in the Desert of Shamo, and on the borders of China, it is comparatively rare except in the central districts already mentioned, and in south-western Asia it is almost unknown. In most of these countries this valuable servant of man occurs chiefly in a domesticated state.

2. *Auchenia* (Llamas). These "camels of the New World" differ from the former species, in being much smaller, and having no hump on the back; but they bear in other respects a strong resemblance to them, both in external and internal structure. They are confined exclusively to South America, and chiefly to the western part of the great chain of the Andes, extending from the wooded islands of Tierra del Fuego, northwards through Patagonia, Chile, Bolivia, Peru, Ecuador, and New Granada, as far as Caracas in Venezuela. As explained in the notes on the perpendicular distribution of Ruminantia, this limitation is determined by the low temperature of the regions referred to; and to this cause also must be ascribed their occurrence in the plains of the southern extreme of the continent. Mr. Darwin[3] states, indeed, that this is the characteristic quadruped of Patagonia. "It generally lives," says the same accurate observer, "in small herds of from half-a-dozen to thirty in each; but on the banks of the S. Cruz, we saw one herd which must have contained at least five hundred." They are observed in great numbers on the northern shores of the Strait of Magalhaens. On the Andes, they are most numerous in Chile and Peru.

3. *Moschidæ* (Musk Deer). This group of ruminants is distinguished from all others by the absence of true horns. The principal species *Moschus moschiferus* (the genuine musk deer), from which the whole group derives its name, forms an important object of the chase in the countries in which it occurs, on account of the substance called musk, which is secreted in a bladder-formed cavity in the abdomen of the male. Its chief habitat is the mountainous countries of Central and South-Eastern Asia, between China and Tartary, and in the regions extending from Lake Baikal to the Altai Mountains; it is also common in Nepaul, Bhotan, Tibet, and the adjacent countries of China and Tonquin. Of the other six species, four occur in India, Ceylon, Sumatra, and Borneo, and two in the countries of Senegambia, Guinea, and Sierra Leone, in Western Africa.

4. The *Cervidæ* (or Deer family) consists of that order of ruminants which have solid horns or antlers. They are generally remarkable for elegance of form, vigour, and speed. The species are very numerous and widely distributed, but our space will only admit of a notice of a few of the more important of them. The largest of this genus, *Cervus alces* (the elk;—the moose deer of America), is an inhabitant of the colder regions both of the Old and the New World. The European elk, which recent investigation proves to be quite a different animal from the American moose, inhabits the forest regions of Scandinavia, Eastern Prussia, Poland, Lithuania, and Russia, as far as Finland and the White Sea, extending eastward through the countries of Asiatic Tartary and Lake Baikal, and southward, occasionally, to the Caucasus. It does not extend to the north of latitude 64° in the Scandinavian Peninsula; and the elk is now extinct in Scania, the southernmost province of Sweden, where once it was very abundant. The American moose deer at one time extended as far south as the Ohio and Cape Breton. They are still found in considerable numbers near the Bay of Fundy, but are not known in the State of Maine. From Dr. Richardson, we learn that they frequent the woody tracts, in the fur countries, to their most northern limits; they probably reach their highest latitude on the shores of the Arctic Sea, near the mouth of the Mackenzie River, latitude 69° north; farther eastward, towards the Coppermine River, they are not found higher than latitude 65°; on the west, they extend beyond the Rocky Mountains as far as the Atna River, where they were observed by Wrangell, in 1839.

Cervus tarandus (the Rein-deer). This valuable animal, the presence of which so materially enhances the comfort and promotes the civilization of the inhabitants of the polar regions, is widely spread over the northern parts of Europe, Asia, and America. The *Caribou*, or rein-deer of America, occurs in greatest numbers between latitude 63° and 66° north; its southernmost limit being about latitude 50°. In Europe, the rein-deer inhabits Iceland, Spitzbergen, Northern Russia, and Scandinavia; but its chief habitat is in Finmark and Lapland. It is also abundant throughout the greater part of Siberia and Kamtchatka.

Cervus dama (the Fallow-deer). This gentle creature, the principal ornament of our parks, is an inhabitant of several European countries, as far as latitude 53° north. It does not occur in Russia proper, but is found in Lithuania, Moldavia, and Greece; it is less common in France and Germany than in England, and is abundant in the wooded districts of the centre and north of Scotland. It extends to the north of Persia and China, and is found in the northern part of Africa, as far south as Abyssinia.

Cervus elaphus (the common Stag or Red-deer) is a native of the temperate countries of Europe (excepting Russia proper), from about latitude 63° north in Scandinavia, southward to the Caucasian Mountains. It also occurs in Siberia, from the regions of the Altai Mountains to the Lena River. In Britain, the range of the stag is now limited to the large parks and chases of England, and to the heath-clad mountains of Scotland, where the largest herds, perhaps, occur on the banks of Lochiel in Argyleshire.

Cervus capreolus (the common Roe or Roebuck) is one of the smallest and most elegant of European deers. It belongs exclusively to the Old World, and is widely distributed over the temperate regions of Continental Europe, as far as latitude 58° north; and in Asia, eastward to the River Lena, in Siberia, and southward to Armenia and Persia. In England, it is still abundant in the wooded districts of Westmoreland and Cumberland; in Scotland, it is very rare to the south of the Forth, but very abundant everywhere to the north of that river. It is unknown in Ireland.

Of the American fallows, the most celebrated is *Cervus Virginianus* (the Virginian Deer), which occurs in all the countries of the New World, from Canada on the north, to Cayenne on the south, but is most abundant in Virginia and Louisiana. The number of species of this and the other families belonging to each separate country will be readily found by reference to the preceding table.

5. *Camelopardalis* (Giraffe). This singular and celebrated animal forms an isolated genus among the ruminants. It is exclusively confined to the continent of Africa, in which there is now ascertained to be at least two species, one of which (*Camelopardalis antiquorum*) inhabits Nubia, Abyssinia, and the adjacent countries to Lake Tchad; and the other (*Camelopardalis Australis*, Sw.), the southern regions of Africa to the Orange and Lion Rivers, in latitude 29° south.

6. *Antilope* (Antelopes). Of this very extensive genus, Africa, as has been already stated, may be considered as the head-quarters, since, as shown on the map, this continent alone contains thirty-four species; while Asia has eleven, Europe two, and America only one. The most celebrated of the whole genus is the European species. *Antilope rupicapra* (the Chamois), which is a denizen of the alpine districts of Europe and Western Asia, namely, the Alps, Pyrenees, the Tatra, and Grecian Mountains, and among the ranges of the Caucasus and Taurus.

7. *Capra* (Goats). These well-known and valuable ruminants, like the preceding, are inhabitants of the alpine regions of Europe; as well as the Taurus Mountains, and Kamtchatka in Asia, and some parts of Africa.

Capra ibex (the Bouquetin or Steinbok). In the Pyrenees, the Alps, and the mountains of the Tyrol, the ibex frequents the loftiest ranges, in the vicinity of the snow line, and appears to ascend even to a greater height than the chamois. The greatest number of species of the goat family occurs in Asia, one of the most celebrated being the goat of Cashmir, which is also spread over Tibet and the countries of the Kirghiz, to the north of the Caspian Sea.

8. *Ovis* (Sheep). These, the most ancient of our domestic animals, may be traced originally to the countries of Western Asia. They herd in flocks, in a wild state, on the inaccessible mountainous districts of Asia, Europe, Africa, and America. Like the goats, they are most numerous in Asia. America furnishes only two species, *Ovis Californiana* and *Ovis montana* (Rocky Mountain Argali)—the latter of which inhabits the chain of the Rocky Mountains, from about latitude 40° to latitude 60° north. They also frequent the elevated ridges intersecting the country between this mountain range and the Pacific, but they have not been observed further to the eastward than the declivity of these mountains, nor are they found in any of the hilly tracts near Hudson Bay.

9. The *Bovine* tribe (Oxen). These comprise the largest of ruminating animals, and consist of groups having a greater or less resemblance to the domestic races of oxen. They are widely distributed, either in a wild or domesticated state, over most countries of the globe. *Bos bubalus* (the buffalo), which has been long known as a domesticated animal in India, has spread thence westwards into Egypt, Greece, Italy, and Spain; and eastwards to China, Cochin-China, and the islands of Sumatra, Java, Borneo, and the Philippines. *Bos Caffer* (the Cape buffalo), is a ferocious animal, which congregates in large herds, and is much dreaded by travellers. It is peculiar to the countries of Southern Africa. The New World furnishes two remarkable species of this order—(1.) *Bos Americanus* (the American bison), which, although its range is much circumscribed, still roams in numerous herds over the remote and uninhabited prairie lands watered by the Arkansas, Platte, Missouri, Saskatchewan, and Peace Rivers, to about latitude 64° north; while, on the south, they extend as far as New Mexico and California. (2.) *Bos moschatus, ovibos mos.* Blainville (the musk ox). This singular animal is considered by many naturalists as forming an appropriate connection between the sheep and the ox. It is peculiar to the frozen regions of North America; its southern range beginning where the northern limit of the bison terminates, and extending thence (latitude 64° north) over the barren regions of the polar districts to Melville Island; thus attaining, with the rein-deer, the highest latitude of any known species of ruminants.

PERPENDICULAR DISTRIBUTION.

In perpendicular distribution, the order Ruminantia affords the most striking examples of the limitation of certain genera and species to particular mountainous regions, in which alone are combined those thermal and climatological conditions which appear to be necessary for their very existence. Of these we shall note some of the most remarkable examples in the different regions of the globe, explanatory of the diagram on the map.

EUROPE.—In the Alps, where the line of perpetual snow reaches a height of 8,700 feet, the *Antilope rupicapra* and *Capra ibex* (chamois and steinbok) attain the greatest height of any of the order; their peculiar habitat being between the upper limit of trees and the snow line, which, on the northern declivities, is about 700 feet lower than on the southern. Oxen graze on the Alps at a height of nearly 8,000 feet, and sheep pasture at a still greater elevation. *Capra elaphus* (the common stag) does not ascend higher into the wooded regions than about 7,000 feet, and *Capra dama* (the fallow deer) about 6,000 feet.

ASIA.—Here, as in the European Alps, goats and sheep attain the highest elevation. Thus the goat of Cashmir (*Capra hircus laniger*), and the argali (*Ovis ammon*), browse on the comparatively naked table-lands of Tibet, at a height of from 10,000 to 13,000 feet above the level of the sea. The *Ovis polii* (the Pamir sheep or rass) lives at the still greater height of 15,600 feet, in the table-land of Pamir, eastward of Bokhara; and the burrhel (*Ovis burrhel*) inhabits the highest ridges of the Himalayan chain, where it is described as "bounding lightly over the incrusted snows, at an altitude where its human pursuers find it difficult to breathe." A specimen in the Museum of the Zoological Society, London, is said to have been shot near the Boorendo Pass, at an elevation of about 17,000 feet—considerably above the line of perpetual snow; and consequently it attains, with the exception of the llama, perhaps the greatest absolute height of any of the Ruminantia. *Bos grunnicus* (the yak or kash-gow) grazes among the snow on the summit of the rugged passes of Tibet. Wherever the mercury does not rise above zero, is a climate for the yak. Indeed, so rigorously is this animal confined to regions of extreme cold, that in the case of two of them being removed to Kabul, though at an elevation of 6,000 feet above the level of the sea, the climate was so ill suited to their nature that they declined as the snow left the ground, and died early in the spring.[4] In the extensive table-lands of Central Asia, the Bactrian camel probably attains a considerable elevation; but this can only be assumed from the fact of its occurrence in the Mongolian plains, the mean height of which is from 3,000 to 5,000 feet.

AFRICA.—The giraffe (*Camelopardalis*) inhabits countries in this continent which rise considerably above 5,000 feet, and the antelopes and buffaloes frequent regions still higher; but there is no exact data on which to found calculations on perpendicular distribution in this quarter of the globe.

SOUTH AMERICA.—Here the llama inhabits the bleak and rocky precipices of the Cordillera de los Andes, in regions bordering on the limit of perpetual snow. On the approach of winter, however, it quits these desolate regions to pasture in the plains; and in Patagonia, the lowness of the temperature permits it to approach the vicinity of the sea. From this it spreads over the elevated regions of the Andes, and in large herds attains, on Chimborazo, the limit of perpetual snow, which there reaches a height of 15,800 feet. On the Bolivian Andes, where the snow line rises still higher, it probably attains a height of 18,000 feet.

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[1] Wood's Journey to the Oxus, p. 321.

[2] It may be necessary again to remind the reader, that in this and the other sheets of the Zoological Division, domesticated animals are not generally taken into account in treating of the distribution of species.

[3] Journal, p. 166.

[4] Wood's Journey to the Oxus, p. 232.

PLATE 29

ZOOLOGICAL GEOGRAPHY.

THE GEOGRAPHICAL DIVISION AND DISTRIBUTION

OF

AVES (BIRDS).

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I. DIVISION AND DISTRIBUTION OF BIRDS OVER THE GLOBE.

BIRDS, forming the second class of vertebrated animals, are divided, by Cuvier, into the following six orders:—

1. Rapaces (Plunderers, or Birds of Prey.)
2. Scansores (Climbers.)
3. Oscines (Songsters.)
4. Gallinaceae (Gallinaceous Birds.)
5. Grallatores (Waders.)
6. Natatores (Swimmers.)

Great diversity of opinion prevails among naturalists as to the proper division of Birds into families and genera, and such are the inherent difficulties of the subject, that no two writers of eminence are agreed as to the manner in which this ought to be accomplished; but it is enough for our purpose to repeat that *species* alone exist in nature, and form the only sure ground-work for accurate statistical details in zoological geography.[1] Birds are richer in species than any other class of the animal kingdom—amounting, at least, to upwards of 6,000, since this number is contained in the Museum of Berlin alone[2]—an amount which is about four times greater than the class Mammalia. And as it is the most numerous, so also it is, with the exception of Fishes, the most widely distributed of all classes of animals; for while, as we have shown in the previous maps of this division of the PHYSICAL ATLAS, mammiferous animals and Reptiles are more or less confined to the warm and torrid zones of the earth, Birds are distributed over every part of the globe, from the equator to the poles. At least, in the highest latitudes to which voyagers have attained, the feathered tribes have never been found entirely absent; of these, the sixth class especially, that of the Swimmers, is most prevalent in arctic regions.

DIVISION AND INTENSITY OF THE SPECIES.

The data for the division and intensity of species over the globe, with the exception of Europe, the map of which forms the second part of this subject, are furnished by Pompper's classification, which is arranged according to Cuvier's system.[3] For this purpose, Pompper divides the globe into sixteen provinces, which, according to the zones, are arranged in three groups. These divisions have been adopted without alteration in the map, except in so far as concerns Europe, which, in the general map, is treated as an undivided province. The following table gives the limits and extent of these sixteen provinces, the numbers in which correspond with those on the map:—

ZONES.	AMERICA.	EUROPE AND AFRICA.	ASIA, OCEANIA, AND AUSTRALIA.
NORTHERN FRIGID ZONE, ...	1. From North Pole to northern boundaries of United States.	4. All Europe.	2. From North Pole to River Obi, and Sea of Ochotsk.
NORTHERN TEMPERATE ZONE, . . .	3. From northern boundaries of United States to northern extremities of the Gulfs of Mexico and California.		5. From River Obi and Sea of Ochotsk to Black Sea and Sea of Japan.
NORTHERN WARM ZONE, ...	6. From northern extremities of the Gulfs of Mexico and California over Central America and the Antilles.	7. From the Mediterranean to southern limits of the Sahara and Nubia.	8. From Black and Japan Seas to Arabian and China Seas.
TROPICAL ZONE, ...	9. From Caribbean Sea to Bolivia and middle of Brazil	10. From the southern limits of the Sahara and Nubia to the southern boundaries of Lower Guinea and Mozambique.	11. From Arabian and China Seas to Little Sunda Isles. 12. Oceania, New Guinea, and Isles in North and East.
SOUTHERN WARM ZONE, ...	13. From Bolivia and middle of Brazil to Bay of Conception and Rio Colorado.	14. From Lower Guinea and Mozambique to Cape Colony.	15. Australia and Isles in East and South.
SOUTHERN TEMPERATE AND FRIGID ZONE,	16. From Bay of Conception and Rio Colorada to South Pole.		

Although the small tables inserted in the map present a complete synopsis of the orders and species in each of the above provinces, it appeared desirable, in order to give a general view of the whole, to compile the following table, in accordance with those inserted in the notes to the other Zoological Maps:—

TABLE SHOWING THE DIVISION OF BIRDS OVER THE GLOBE.

ORDERS.	ZOOLOGICAL PROVINCES.															
	NORTHERN FRIGID Z.		NORTHERN TEMPERATE ZONE.			NORTHERN WARM ZONE.			TROPICAL ZONE.				SOUTHERN WARM ZONE.			S. TEMPER. AND FRIGID Z.
	America. 1	Asia. 2	America. 3	Europe. 4	Asia. 5	America. 6	Africa. 7	Asia. 8	America. 9	Africa. 10	Asia. 11	Oceania. 12	America. 13	Africa. 14	Australia. 15	America. 16
	Number of the Species.															
1. Rapaces (Birds of Prey), . .	10	4	22	54	14	11	26	12	53	11	31	4	9	28	3	3
2. Scansores (Climbers), . . .	5	2	12	23	7	23	8	4	122	21	86	26	18	30	26	3
3. Oscines (Songsters), ...	14	9	72	186	20	72	67	16	319	113	192	69	52	107	51	5
4. Gallinaceae (Gallinaceous Birds),	4	5	10	28	8	15	17	20	45	22	72	15	5	12	24	2
5. Grallatores (Waders), . . .	21	24	36	87	26	20	38	23	59	25	50	11	16	30	18	4
6. Natatores (Swimmers), . . .	49	39	26	112	28	15	8	10	26	19	19	8	18	22	30	29
Amount of Species, ...	**103**	**83**	**178**	**490**	**103**	**156**	**164**	**85**	**624**	**211**	**450**	**133**	**118**	**229**	**152**	**46**

This table shows the remarkable fact, that whilst, in general, the number of species is greatest in tropical countries, Europe forms such a striking exception, that it possesses more species than any other province, with the exception of that of tropical America, more even than tropical Asia and the Sunda Islands together. Still, however, we perceive that the gross number of species increases in the tropical provinces; and this is the case also with the single orders, except that of the Natatores, which, on the contrary, decreases in the direction of the equator. Europe and tropical America possess the greatest number of Rapaces, whilst the Scansores and Oscines are also most abundant in the latter country. In tropical Asia the greatest number of Gallinaceae occurs, and the Grallatores and Natatores are most numerous in Europe.

DISTRIBUTION OF SOME OF THE FAMILIES, GENERA, AND SPECIES.

ORDER I.—RAPACES. Among the family of the *Vulturinae* the most remarkable is *Vultur gryphus* (Condor or Cuntur), the largest of all flying Birds.[4] The habitat of this Vulture is confined exclusively to the vicinity of the Andes chain in South America, it appears not to extend even to the table-land of Mexico, and is not found in any other part of the globe. According to the observations of A. Von Humboldt, the breeding place chosen by the Condor is at an elevation of from 10,000 to 15,000 feet above the level of the sea, where they may be seen in groups of three or four, but never in large companies, like the true Vultures. They are often seen at a great height, soaring over a certain spot in the most graceful circles. On some occasions, Mr. Darwin remarks, they do this for pleasure, but on others they are watching a dying animal, or the puma devouring its prey. On one occasion, Humboldt saw this enormous bird floating over the summit of Chimborazo, at an elevation of upwards of 22,000 feet, or six times higher than the region of clouds. From these lofty regions he descends only when driven by the pressure of hunger, in order to seek his food on the sultry shores of the sea; where, however, he cannot long remain, since his nature limits him to a temperature which ranges from 25° to 26°. The Condor is distributed over the whole of the Andes chain, on the west side of South America, from the Strait of Magalhaens to latitude 7° north, where, in the province of Antioquia, he attains his northernmost limit, probably because here the Cordillera loses its colossal height. On the southern limits of its distribution the Condor quits the Andes chain, and roams over the plains of Patagonia, where he is found at the mouth of the Rio Negro, in latitude 41° south, having wandered 400 miles from the great central line of his habitation in the Andes. *Vultur aura* (urubu), and *Vultur Papa* (King Vulture), are two other South American species, the latter of which extends to Florida and Mexico. *Vultur Jota* (Black Vulture) is distributed over the countries from South Carolina, Savannah and Georgia, in North America, to latitude 41° south, where it abounds in Brazil and La Plata, while it is never found in the desert and arid plains of Northern Patagonia, nor even in Chile. The Vulture which is figured among the types of the Birds of the Old World, *Vultur Kolbii*, is dispersed throughout the countries of Africa and India; it is very abundant in Southern Africa, and occasionally visits the Island of Sardinia.

ORDER II.—SCANSORES. The family *Psittacidae* (Parrots). This extensive and very interesting family, remarkable for the beautiful colours of their plumage, and their power of imitating the human voice, belongs chiefly to the countries within the torrid zone; but they occur also in temperate regions, and are abundant in the Southern Hemisphere, where they are found even in high latitudes, inhabiting not only the southern extremity of South America, as far as the Strait of Magalhaens, but Australia, Van Diemen's Land, New Zealand, and even Macquarie Island, latitude 56° south. In the Northern Hemisphere they appear to attain their highest latitude, by the occurrence of the species *Psittacus Carolinensis* (Carolina Paroquet), in the United States, latitude 42° north: where they join the southern limits of the Eider Duck. Another remarkable circumstance in the distribution of this family is, that while nearly forty species occur in the tropical regions of South America, only three species are known to inhabit the opposite coast of Africa, which is situated under the same latitude, and possesses a vegetation almost equally luxuriant. It is doubtful whether they attain, in this continent, the latitude of 30° south.—We shall now refer to two other families, one of which occurs only in the Old, and the other in the New World. The family *Paradiseidae* (Birds of Paradise), which hold the highest rank among the feathered glories of creation, are limited to a very small district; and it is singular that the most beautiful of nature's productions should have assigned to it a region whose inhabitants are the most rude and savage of the whole human race; for the country of the Papuas—New Guinea, and the neighbouring islands—with the Moluccas and the Aroo Islands, form the exclusive habitat of the Paradiseidae. They are birds of passage, and change their quarters according to the monsoon.—The family of the *Rhamphastidae* (Toucans and Araçaris), are all natives of tropical America, between the countries of Guayana and the Rio de la Plata, but chiefly in Brazil, where they live retired in the depths of the forests.

ORDER III.—OSCINES. The family *Trochilidae* (Humming Birds). These—the smallest and most brilliant of Birds—are all natives of the countries of the New World, being nearly confined to the tropical portions of America. They are most abundant in the islands of the West Indian Archipelago, and on the continent of South America, from the mouth of the Orinoco to beyond the Tropic of Capricorn. But some species are found at a great elevation, and others at a very high latitude. Mr. Bullock observed them on the lofty table-lands of Mexico, and in the woods on the snowy mountain of Orizaba; and Mr. Darwin found a species in the Cordillera of the Andes, at an elevation of 10,000 feet, while they were met with in great numbers near the Strait of Magalhaens, flying about in a snow storm; and Captain King discovered two species in the Island of Juan Fernandez. On the north the ruby-throated Humming Bird was found breeding, near the sources of the Elk River, in the plains of the Saskatchewan; and Wrangell, during his travels in 1833, states that this bird occurs at the mouth of the Atna River, but that it is not to be seen farther to the south or west; but Kotzebue remarks that he observed it on the north-western shores of America, in Behring Strait to latitude 61° north.

ORDER IV.—GALLINACEAE. It will be seen, from the preceding table, that this order is not nearly so numerous in the New as in the Old World. Here the genus *Phasianus* (Pheasant) extends from the regions of the Caucasus, over Tibet, through the whole of Central Asia, the Malay Peninsula, and Cochin-China, to China and Japan, including the islands of Sumatra and Java; while the genus *Pavo* (Peacock), though not so widely spread as the former, yet extends over India, Tibet, China, Japan, and the Indian Archipelago; *Pavo cristatus* (Common Peacock) is a native of India, where it is common in many districts, and abundant in the jungles along the banks of the Ganges, in the forests of Jungletery and Baughalpore districts, and in the dense forests of the Ghauts. *Meleagris gallopavo* (Turkey) is peculiar to the New World. Its native country appears to extend from the north-west territory of the United States to the Isthmus of Panama. It is not found to the southward of this, nor to the westward of the Rocky Mountains. In former times it was common in many parts of Canada; at present it is most abundant in the States of Kentucky, Illinois, and Indiana.

ORDER V.—GRALLATORES. The gigantic family *Struthionidae* (Ostrich, Rhea, Cassowary, &c.), inhabits the countries of Africa, America, Australia, the Indian Archipelago, &c. The African species, *Struthio Camelus* (the Ostrich or Camel Bird of the Arabs), is the tallest of the class to which it belongs, and probably the fleetest of all running creatures, surpassing in speed the fastest horse or the swiftest greyhound. It is spread over the sandy deserts of the greater part of Africa, from the parallel of Biskara in Barbary to the Cape of Good Hope; it appears not to have been observed on the coast of Guinea or on the shores of the Indian Ocean; but it was met with by Adanson in the sandy plains of the Lower Senegal. In Arabia, the Ostrich inhabits the deserts, chiefly in the plains of Nedjed. In ancient times it extended to India, and, in the fifteenth century, it was found on the southern declivity of the Caucasus, and on the shores of the Black Sea. Of the two other species of Struthionidae belonging to the Old World, *Casuarius Indicus s. Casoar* (Cassowary) inhabits the south-eastern peninsula of Asia and the Indian Archipelago, where it is found in Sumatra and Java, as well as in Banda; and it is very common in New Guinea, and in the dense woods of the southern coast of Ceram, and also in Bantong, and the Aroo Isles. *Casuarius Novae Hollandiae* (Emu or Australian Cassowary) is widely distributed over the southern coast of Australia, and the islands in its vicinity. They have been observed on the west coast at Swan River; and Captain Flinders found them in great numbers at Port Philip, King George Sound, and on Kangaroo Island, as well as in Carpentaria. In the New World the Ostrich is represented by two species of Rhea; *Struthio Rhea*, and *Rhea Darwinii*—the first, which till recently, was the only species known in America, is the Nhandu-Guaçu of Brazil, where, and in Guayana, it is very numerous. It is abundant in the plains of the Rio de la Plata, but has not crossed over the Cordilleras: it has been met with, however, in the plateau of the Uspallata Mountains, at a height of from 6,000 to 7,000 feet. On the south it appears to extend to the Rio Negro, in latitude 41° south, where it is replaced by the *Struthio Darwinii*. This species, recently observed by Mr. Darwin, extends from the banks of the Rio de Janeiro to the Strait of Magalhaens, in about 54° south latitude.

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[1] See Notes to Zoological Geography, plate 1.

[2] Lesson, who, during ten years, has been occupied in compiling a list of all known living Birds, has enumerated 6,266 species in 1,075 genera.

[3] Die Säugethiere, Vögel und Amphibien nach ihren geographischen Verbreitung tabellarisch zusammengestellt von Dr. Hermann Pompper, Leipzig, 1841.

[4] Mr. Darwin shot one in Patagonia, which measured, from tip to tip of the wings, eight and a-half feet, and from beak to tail four feet.—*Darwin's Journal*, p. 172. Humboldt reckons the largest individuals found in the Andes of Quito at fifteen feet, and the smallest about eight and a half feet.—*Tableau de la Nature*, t. xi., p. 73

ORDER VI.—NATATORES. Of this order, one of the most important is genus *Somateria* (Eider Duck), celebrated for the delicate, soft, and elastic down so well known in commerce. Its chief habitat appears to be the shores of the Arctic Ocean. It is abundant on the shores of Davis Strait, Baffin and Hudson Bay, as well as in Greenland, Iceland, Spitzbergen, Norway, and Lapland, and in the islands of Behring, the Kuriles, the Hebrides, and Orkneys; it is less common in Sweden and Denmark, and in Germany it is only observed as a passenger. In America, according to Audubon, it does not range farther south than the vicinity of New York. Its southernmost breeding place in Europe is the Fern Islands, on the coast of Northumberland.—The family of the *Spheniscidae* (Penguins) is most common in the high latitudes of the Southern Hemisphere; it is abundant at the Strait of Magalhaens, the Falkland Islands, the Islands of Tristan da Cunha, Amsterdam Island, Macquarie Island, and the southern shores of Australia; it has been observed even at the Cape of Good Hope, and Lesson killed individuals in 43° 8′ south latitude, and 57° west longitude.

PERPENDICULAR DISTRIBUTION OF BIRDS.

Birds are the most favoured of all animals in their powers of locomotion, yet they form no exception to the general rule already so often referred to—different species being limited, like the families of plants and quadrupeds, to different regions of the surface of the globe. But their peculiar structure enables them to penetrate into the higher regions of the atmosphere, and to soar above the clouds to such an elevation as man himself cannot boast of.

Birds of Prey ascend highest, and, as we have seen in the preceding notes, the Condor may with ease reach a height of more than 22,000 feet. *Vultur aura* (Turkey Buzzard), *Vultur Papa* (King Vulture), *Vultur Jota* (Black Vulture), occur in the Andes of South America, between the upper limit of trees and the snow line, or at an elevation of from 12,000 to 16,000 feet. In the same region many species of Falcon are found. Among the *Climbers*, *Psittacus militaris* (Green Macaw), attains to an elevation of about 3,000 feet in the Andes. Of the *Songsters*, *Caprimulgus grandis* (Ibijau), is found at a height of from 12,000 to 16,000 feet, and the genus *Cassicus*, between 7,000 and 8,000 feet; but the genus *Ampelis* (Chatterers), is never met with higher than 3,000 feet. Among the *Waders*, the Nandu, already referred to, visits the plateaus situated at an elevation of from 6,000 to 7,000 feet; and the genera Colymbus and Anas among the *Swimmers*, reach a height of nearly 10,000 feet in the Andes.

II. GEOGRAPHICAL DIVISION AND DISTRIBUTION OF BIRDS IN EUROPE.

DIVISION AND INTENSITY OF THE SPECIES.

The basis of this representation is the systematic catalogue of European Birds by Keyserling and Blasius,[1] containing in all 490 species, which are divided into 34 families and 164 genera. The names of these families and genera are given in the following table.

Europe is divided into five zoological provinces, of which the Northern and North-eastern extend from the extreme northern regions to latitude 60° north, or rather to the isotherm curve of 41°, while it is divided into an eastern and western portion by a line passing somewhere about the meridian of Archangel. The Central European province extends southward to the crest of the Pyrenees and the Alps, and borders on the South-eastern province, which embraces Southern Russia, and the countries on the north side of the Black Sea, from the Uralian Mountains to the Caspian Sea. The South European province consists of the three peninsulas of Spain, Italy, and Greece, and the islands of the Mediterranean Sea. But the European Birds spread themselves far beyond the limits of their native country, extending southward to the interior of Africa, and many of them over the whole of Asia. For this reason we have extended the map over the adjoining countries to Central and Tropical Asia. In consequence of this extension of European species, Asia forms the second great region, and is likewise divided into five provinces. The two northern provinces, Eastern and Western Siberia, which are nearly divided by the course of the Yenesei River, extend to the same latitude as the two corresponding European provinces, namely, to the isotherm curve of 41°. The province of Central Asia extends southward to the chain of the Himalaya Mountains; and that of South-western Asia embraces the countries of the Caucasus, Asia Minor, Armenia, Syria, Persia, &c., to the chain of the Solyman Mountains, where the province of Tropical Asia begins. All these divisions correspond with those adopted in the notes to the Map of Carnivora, No. 4 of this division.

TABLE SHOWING THE DIVISION OF THE EUROPEAN BIRDS.[2]

_ The large figures indicate the entire number of species belonging to each order, and the small figures their division in the different regions. For example, in the order Rapaces, the amount of all species is 54, of which, the family Vulturinae, with the genera Neophron, Vulture, &c, comprises five species, none of which occur in North or North-east Europe, but three in Central Europe, two in South-east, the whole five in Southern Europe &c.

ORDERS, FAMILIES, AND GENERA, WITH THE NUMBER OF THEIR SPECIES.		EUROPE.					NORTH AFRICA.	ASIA.				
		Northern.	North-east.	Central.	South-east.	Southern.		Western Siberia.	Eastern Siberia.	Central.	South-west.	Tropical Asia or India.
		Number of the Species.										
I. RAPACES (BIRDS OF PREY),	**54**	**28**	**28**	**37**	**31**	**41**	**27**	**16**	**23**	**14**	**20**	**5**
1. Vulturinae (Vultures):—Neophron 1, Vultur 2, Gyps 1, Gypaëtos 1,	5	.	.	3	2	5	3	.	.	1	2	.
2. Falconinae (Hawks):—Falco 10, Elanus 1, Nauclerus 1, Pandion 1, Circaëtos 2, Pernis 1, Buteo 2, Aquila, 5 Haliaëtos 3, Milvus 2, Astur 2, Circus 4,	34	17	20	22	24	28	21	13	16	10	12	4
3. Striginae (Owls):—Strix 1, Ulula 4, Aegolius 2, Nyctale 1, Surnia 4, Bubo 2, Ephialtes 1,	15	11	8	12	5	8	3	3	7	3	6	1
II. SCANSORES (CLIMBERS),	**23**	**12**	**12**	**14**	**15**	**21**	**9**	**7**	**11**	**2**	**5**	**1**
4. Cypselinae (Swifts):—Cypselus 2,	2	1	.	1	.	2	1	1	1	.	1	.
5. Caprimulginae (Goatsuckers):—Caprimulgus 3,	3	1	1	2	1	3	.	1	2	.	.	.
6. Cuculinae (Cuckoos):—Cuculus 1, Coccystes 2,	3	1	1	2	1	3	2	1	1	.	1	.
7. Picinae (Woodpeckers):—Jynx 1, Picus 8,	9	7	8	7	7	8	.	1	6	.	.	.
8. Alcedinae (Kingfishers):—Alcedo 2, Merops 2, Coracias 1,	5	1	1	1	5	4	5	2	1	1	2	1
9. Upupinae (Hoopoes):—Upupa 1,	1	1	1	1	1	1	1	1	.	1	1	.
III. OSCINES (SONGSTERS),	**186**	**70**	**57**	**122**	**100**	**120**	**62**	**51**	**45**	**50**	**65**	**12**
10. Alaudinae (Larks):—Alaemon 1, Alauda 3, Phileremos 4, Melanocorypha 2,	10	2	2	4	7	6	5	3	1	1	6	1
11. Fringillinae (Finches):—Plectrophanes 2, Emberiza 13, Passer 2, Pyrrhula 8, Fringilla 14, Coccothraustes 1, Loxia 3,	43	19	11	25	21	21	9	12	15	13	19	.
12. Sittinae (Nuthatchers):—Aegithalus 1, Calamophilus 1, Parus 9, Sitta 3, Bombycilla 1, Garrulus 2, Nucifraga 1, Pica 2, Corvus 6, Pyrrhocorax 1, Fregilus 1,	28	20	13	20	15	18	1	10	12	13	3	.
13. Oscininae (Songsters):—Sturnus 1, Merula 1, Troglodytes 1, Certhia 1, Tichodroma 1, Cinclus 1, Anthus 7, Motacilla 6, Oriolus 1, Petrocichla 2, Turdus 13, Accentor 3, Salicaria 15, Regulus 3, Ficedula 6, Sylvia 12, Lusciola 9, Saxicola 7, Lanius 6, Muscicapa 4,	100	26	28	70	53	70	43	23	14	21	35	10
14. Hirundinae (Swallows):—Hirundo 5,	5	3	3	3	4	5	4	3	3	2	2	1
IV. GALLINACEAE (GALLINACEOUS BIRDS),	**28**	**6**	**4**	**21**	**12**	**21**	**12**	**6**	**4**	**9**	**14**	**2**
15. Columbinae (Pigeons):—Columba 5, Ectopistes 1,	6	.	.	5	4	5	4	2	.	4	4	.
16. Pteroclinae:—Pterocles 2,	2	.	.	.	2	2	1	.	.	2	2	.
17. Gallinae (Fowls):—Lagopus 3, Tetrao 2, Tetrastes 1, Phasianus 1, Gallus 1, Pavo 1, Meleagris 1, Numida 1, Attagen 1, Perdix 3, Starna 1, Ortyx 1, Ortygion 1,	18	6	4	16	6	12	6	4	4	3	8	2
18. Ortyginae (Colins):—Ortygis 2,	2	.	.	.	.	2	1	.	.	.	.	.
V. GRALLATORES (WADERS),	**87**	**32**	**29**	**57**	**64**	**54**	**43**	**50**	**30**	**39**	**34**	**8**
19. Cursitrinae (Runners):—Glareola 1, Cursorius 1,	2	.	.	1	1	2	2	1	.	1	1	.
20. Otinae (Bustards):—Otis 3,	3	.	.	2	3	3	2	2	.	2	2	.
21. Gallinulinae (Gallinules):—Crex 1, Ortygometra 3, Rallus 1, Gallinula 1, Fulica 1, Porphyrio 1,	8	.	.	7	2	8	3	5	.	2	3	.
22. Gruinae (Cranes):—Grus 4,	4	1	1	1	4	2	2	3	1	3	3	3
23. Pluvialinae (Plovers):—Oedicnemus 1, Hoplopterus 1, Vanellus 2, Squatarola 1, Charadrius 1, Eudromias 2, Aegialites 4, Strepsilas 1, Haematopus 1,	14	7	6	8	10	7	5	5	6	6	5	2
24. Scolopacinae (Snipes):—Recurvirostra 1, Hypsibates 1, Totanus 7, Actitis 3, Phalaropus 2, Limosa 3, Macroramphus 1, Machetes 1, Calidris 1, Falcinellus 1, Tringa 8, Limicola 1, Ascalopax 4, Scolopax 1, Numenius 3,	38	23	21	30	28	19	16	25	22	15	9	2
25. Ibidinae (Ibis):—Ibis 1,	1	.	.	.	1	.	1	1	.	.	1	.
26. Ardeinae (Herons):—Ardea 11,	11	1	1	4	10	10	7	6	1	7	6	1
27. Ciconinae (Storks):—Ciconia 3, Tantalus 1, Platalea 1,	5	.	.	4	4	2	4	2	.	2	3	.
28. Phoenicopterinae (Flamingos):—Phoenicopterus 1,	1	.	.	.	1	1	1	.	.	1	1	.
VI. NATATORES (SWIMMERS),	**112**	**64**	**55**	**54**	**37**	**37**	**21**	**73**	**57**	**23**	**19**	**4**
29. Anatinae (Ducks):—Cygnus 3, Anser 9, Chenalopex 1, Vulpanser 2, Anas 7, Rhynchaspis 1, Cairina 1, Somateria 2, Oidemia 3, Undina 1, Glaucion 2, Harelda 3, Fuligula 5, Mergus 4,	44	30	29	24	18	9	6	31	30	14	11	2
30. Pelecaninae (Pelicans):—Phalacrocorax 5, Pelecanus 3, Sula 1,	9	3	3	2	3	3	2	5	3	1	2	.
31. Podicepinae (Grebes and Loons):—Podiceps 5, Colymbus 3,	8	5	5	5	4	5	2	7	6	5	3	.
32. Alcinae (Auks):—Alca 2, Lunda 1, Mergulus 1, Uria 5,	9	9	7	.	.	.	.	7	7	.	.	.
33. Procellarinae (Procellarine Birds):—Thalassidroma 3, Oceanites 1, Procellaria 1, Nectris 4,	9	4	3	6	.	1	.	2	2	.	.	.
34. Sterninae (Terns):—Lestris 4, Larus 18, Sterna 10, Megalopterus 1,	33	13	8	17	12	19	11	18	9	3	3	2
AMOUNT OF SPECIES,	**490**	**212**	**185**	**305**	**259**	**294**	**174**	**202**	**170**	**139**	**157**	**32**

PERPENDICULAR DISTRIBUTION OF BIRDS IN THE ALPS.

As in the distribution of the fauna of the temperate zone in Europe,[3] we find this part of our map best illustrated by the judicious remarks on the zoology of the Valley of Ursern, from the observations of the same enlightened naturalist to whom we formerly referred. Schinz remarks, that the highest inhabited valleys, and the Alpine passes of Europe, afford the most interesting opportunities for observations on zoological geography, since the appearances met with there, when compared with those in other situations, may lead to an understanding of the laws which regulate the distribution of animal life over the globe, and especially of that which determines the seasons of the migrations of Birds. Travellers cannot furnish the necessary details; to be of any value, they must, like the following, be the result of many years' observations by a resident on the spot.

The Valley of Ursern, to which these observations apply, is one of the highest inhabited Alpine valleys in Europe, the lowest part of which is 4,640 feet above the level of the sea; and it is surrounded by the highest peaks of the mountain of St. Gothard. A rude and cold climate places it beyond the proper region of trees, which attain nearly their highest limits at the entrance of the valley, and only the hardy pine is able to maintain its existence. Along the banks of the Reüss, shrub-like alders and willows occur, but they also cease to grow at a height of 4,870 feet in the Valley of Hospen. At the Hospice of St Gothard, 6,867 feet above the level of the sea, in a valley which for eight months of the year is covered with snow, and where the meadows afford but little shelter, it may be inferred that few animals could find a permanent residence; yet although it is mostly visited by hunting animals and birds of passage, its proper fauna is more numerous than could have been anticipated; and the ornithologist, especially, meets with phenomena which must be new to him. Welden remarks, that in their flight, birds of passage choose the lowest valleys of the Alps, and hence they cannot be so frequently met with in the higher passes; but it is ascertained that the greater number pass over the great St. Bernard, the pass of St. Theodule, the Simplon, and the St. Gothard. The following table[4] shows the number of species of each of the six orders which inhabit these lofty regions; and the diagram on the map points out the elevation at which they occur, as well as several others which ascend beyond the limits of snow. The list contains 139 species, or nearly one-half of all the Birds, residents or passengers, which occur in Central Europe:—

I. RAPACES,	**12**	12. Tichodroma,	1	28. Alauda,	1	39. Numenius,	1
1. Gypaëtos,	1	13. Corvus,	7	29. Parus,	5	40. Scolopax,	2
2. Aquila,	2	14. Oriolus,	1	30. Hirundo,	3	41. Tringa,	6
3. Falco,	5	15. Lanius,	4	31. Micropus,	1	42. Vanellus,	1
4. Strix,	4	16. Sylvia,	16			43. Rallus,	1
		17. Regulus,	2	**IV. GALLINACEAE,**	**8**	44. Crex,	1
II. SCANSORES,	**8**	18. Accentor,	2	32. Columba,	2	45. Gallinula,	3
5. Picus,	4	19. Anthus,	3	33. Tetrao,	4	46. Morinella,	1
6. Jynx,	1	20. Loxia,	1	34. Perdix,	2	47. Phalaropus,	1
7. Upupa,	1	21. Fringilla,	11			48. Fulica,	1
8. Cuculus,	1	22. Emberiza,	3	**V. GRALLATORES,**	**26**		
9. Alcedo,	1	23. Cinclus,	1	35. Charadrius,	3	**VI. NATATORES,**	**7**
		24. Turdus,	7	36. Arenaria,	1	49. Anser,	1
III. OSCINES,	**78**	25. Sturnus,	1	37. Ardea,	3	50. Anas,	3
10. Sitta,	1	26. Muscicapa,	3	38. Grus,	1	51. Podiceps,	1
11. Certhia,	1	27. Motacilla,	3			52. Larus,	2

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[1] Die Wirbelthiere Europa's, von A. Graf Keyserling, und Professor J. H. Blasius. Braunschweig, 1840.

[2] The limits of some of the most important species, in each of the six orders, are defined by colours on the map, in the same manner as in the other maps of this division; and the names of countries, rivers, and places, are inserted, when required, to explain them; thus it will be found that Fountainebleau forms the extreme limit of the Golden Eagle in the low lands of France. Doncaster forms the northern limit of the nightingale in Britain, &c.

[3] See Notes to Map No. 4 of this division, p. 85.

[4] In this table the classification and nomenclature of Schinz are retained.

PLATE 30

ZOOLOGICAL GEOGRAPHY.

THE GEOGRAPHICAL DIVISION AND DISTRIBUTION

OF

REPTILIA (REPTILES).

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

The class of Reptiles—which, of all animals of higher organization, are regarded by man with the greatest suspicion and mistrust, being considered more baneful than useful, more as objects of aversion and dread than of interest and attraction—present by far the most wonderful diversity of form and structure. Thus the difference between the form of the long, trailing snake, and the ponderous, shield-covered tortoise, is much greater than that between the elephant and the mouse, or the eagle and the humming-bird. Reptiles are divided into the following four orders:—*Testudines* (Tortoises), *Sauria* (Lizards), *Ophidia* (Serpents), and *Batrachia* or *Amphibia* (Frogs). These four orders are subdivided into twenty-six families, and these, again, according to different classifications, form from seventy to one hundred genera. The number of living species which are not only known and described, but of which the habitat is ascertained, amounts, according to the most recent calculations, to six hundred and fifty-seven. This is by far the smallest number of species belonging to any of the four classes of vertebrated animals; but it is necessary to bear in mind that the number of those whose habitat is not ascertained must amount to some hundreds more, and C. Bonaparte, in 1832, reckoned the whole at nine hundred and forty-five, including the fossil species.

In regard to the distribution of Reptiles over the globe, a glance at the map will show that they are, to a much greater extent than any of the three other classes of vertebrated animals, limited to the countries of the torrid zone; only a few of the smaller genera occur in the countries of the temperate zone. In fact they can more easily bear the rigours of a severe winter, than suffer the absence of a hot summer; hence in Scandinavia, although the species are very few in number, the individuals are much more numerous than in Britain. Very few species reach the isothermal line of 32°, and still fewer extend beyond it. The Frogs generally extend farthest towards the polar regions; yet a species of Lizard (*L. ocellata*) has been discovered as far north as Kamtchatka, through the southern part of which the isothermal line of 32° passes. Indeed, the common Water Frog (*Rana esculenta*) extends to a much higher latitude in Finland, although it does not reach the isothermal line of 32°. In the New World, the Frogs extend beyond this line in Greenland and British America. On the banks of the Mackenzie River Frogs and Salamanders are known to extend to the 67th degree of latitude, where the mean temperature is not above 7° or 8° of Fahrenheit, and where the cold in winter sometimes descends to more than 90° below the freezing point. The farthest point to which Reptiles have been ascertained to extend in the Southern Hemisphere is latitude 50° south, where, on the banks of the river Santa Cruz, a frog was observed by Mr Darwin. The shadings on the map, too, will indicate that the great river courses, estuaries, and level tracts of continents, together with the smaller low lying islands of tropical seas, are the chief haunts of the Reptilia.

DIVISION AND INTENSITY OF THE SPECIES.

If the Reptile fauna of all countries were as thoroughly known as it is, for example, in the small state of Connecticut, the result attained, as to comparative numbers, would, doubtless, be very different from that we now possess, which gives for Connecticut fifty-six,[1] and for the whole of Asia (with the exception of the East Indies) only forty-four species. In the following table we have attempted to present a complete view of the division of the four orders of Reptiles and their families over the globe, with the exception of the Serpents, of which we shall treat in the second section of this paper. In representing the intensity of species in this map, we have endeavoured to combine the principles adopted in the first two maps of this division. The comparative amount of species is indicated by shading, as in the first, and, at the same time, the world is divided into provinces, in each of which synoptical tables are inserted, as in the second map. The number of provinces in this map is limited to seven, which are divided according to the zones, namely, three Torrid, three Temperate, and one Austral province. These provinces, with the number of species of their entire fauna, are, next to the division of Reptiles over the globe, also given in the annexed table:—

TABLE SHOWING THE DIVISION OF *REPTILES* OVER THE GLOBE.

ORDERS and Families of the REPTILES, with the Number of their Species.	Europe.								Asia.											
	Great Britain.	Scandinavia.	Russia and Poland.	France.	Germany and Switzerland.	Iberian Peninsula.	Italy, with Isles.	Turkey and Greece.	Northern and Central Asia.	Asia Minor.	Arabia and Persia.	China and Eastern Peninsula.	Japan.	Hindustan and Ceylon.	Philippine Islands.	Sumatra.	Java.	Borneo.	Celebes.	Molucca Islands.
	Number of the Species.																			
I. TESTUDINES (Tortoises), 69	.	.	1	2	1	.	5	2		1	4	1	.	7	.	8	10	8	1	6
1. Terrestrial or Land Tort. 15	.	.	.	.	.	.	1	2	.	1	.	.	.	2	.	1	.	.	.	1
2. Fresh-water Tortoises																				
a Marsh Tortoises, . . 36	.	.	1	2	1	.	2	.	.	.	2	.	.	3	.	4	5	5	1	2
b Fluviatile or River T. 10	.	.	.	.	.	.	.	.	.	.	4	.	.	2	.	3	5	3	.	.
3. Marine Tortoises or Turtles, 8	.	.	.	.	.	.	2	.	.	.	1	1	.	.	.	.	.	.	.	3
II. SAURIA (Lizards), . . 203	3	2	2	12	3	14	20	7	5	9	6	8	.	13	1	10	18	10	1	9
4. Crocodilidae (Crocodiles), 13	.	.	.	.	.	.	.	.	.	.	1	1	.	2	.	1	2	.	.	.
5. Chamaeleonidae (Chameleons), ... 7	.	.	.	.	.	1	1	.	.	2	1	.	.	1	.	.	.	.	.	1
6. Geckotidae (Geckos), . . 27	.	.	.	2	.	2	4	2	.	3	2	.	.	3	.	1	3	1	.	1
7. Iguanidae (Iguanas), . . 55	.	.	.	1	.	1	1	.	.	1	.	3	.	3	1	2	5	2	.	4
8. Varanidae (Varans, Monitors, &c.), ... 15	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	3	2	3	1	2
9. Teidae (Teguixins), ... 11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10. Lacertidae (True Lizards), 20	2	2	1	5	2	3	5	2	4	1	1	2	.	.	.	.	2	.	.	.
11. Chalcidae (Chalcis, Saurophis, &c.), ... 16	.	.	1	.	.	2	1	2	1	.	.	.	.	.	.	.	.	.	.	.
12. Scincidae (Skinks), ... 39	1	.	.	4	1	5	8	1	.	2	1	1	.	3	.	3	4	4	.	1
III. OPHIDIA (Serpents), 265 (Containing the Families 13–21.)	3	3	3	8	9	9	11	12	6	5	4	14	6	51	9	26	56	.	16	11
IV. AMPHIBIA (Frogs), 120	8	5	4	9	8	6	11	6	3	5	1	1	4	4	.	.	.	.	.	.
22. Caeciliadae (Caecilias), . . . 5	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
23. Ranidae (True Frogs), . . . 81	4	4	3	7	5	4	7	5	3	4	1	1	4	3	.	.	.	.	.	.
24. Salamandridae (Tritons and Newts), ... 26	4	1	1	2	2	2	4	1	.	1	.	.	.	.	.	.	.	.	.	.
25. Amphiumidae (Amphiuma, &c.), ... 2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
26. Proteidae (Proteus, Axolotl, &c.), 6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
AMOUNT OF THE SPECIES OF ALL REPTILES, ... 657	14	10	10	31	21	29	47	27	14	20	15	24	10	75	10	44	84	18	18	26

ORDERS and Families of the REPTILES, with the Number of their Species.	Africa.						America.								Australia, &c.			Zoological Provinces of the Map.						
							N. America.				S. America.							Temperate Provinces.			Tropical Provinces.			
	Barbary.	Egypt, Nubia, and Abyssinia.	Western and Central Africa.	Cape Colony.	Madagascar.	Bourbon, Mauritius, & Seychelles.	British America.	United States.	Mexico and California.	Central America and West Indies.	Guayana and Colombia.	Brazil.	Paraguay and La Plata.	Chile and Peru.	Australia.	New Guinea.	New Ireland, Marianne Islands, &c.	North America.	Europe.	Asia, without the East Indies.	Central and South America.	Africa.	East Indies.	Australia and Oceania.
	Number of the Species.																							
I. TESTUDINES (Tortoises), 69	6	3	4	3	2	3	1	19	4	6	7	13	1	.	3	2	.	21	6	4	18	15	23	5
1. Terrestrial or Land Tort. 15	3	1	1	3	1	2	.	.	1	2	1	3	1	.	1	1	.	1	2	1	4	7	3	2
2. Fresh-water Tortoises																								
a Marsh Tortoises, . . 36	1	.	1	.	.	.	1	14	2	1	3	9	.	.	2	.	.	15	2	2	7	2	11	2
b Fluviatile or River T. 10	.	1	.	.	.	.	.	2	.	.	1	.	.	.	.	.	.	2	.	.	1	1	6	.
3. Marine Tortoises or Turtles, 8	2	1	2	.	1	1	.	3	1	3	2	3	.	.	.	1	.	3	2	1	6	5	3	1
II. SAURIA (Lizards), . . 203	24	28	5	17	1	11	3	8	6	12	19	46	2	2	9	5	1	13	29	17	67	69	45	14
4. Crocodilidae (Crocodiles), 13	.	1	1	.	.	1	.	1	2	2	1	4	1	.	1	.	.	3	.	1	6	3	4	1
5. Chamaeleonidae (Chameleons), ... 7	2	2	.	1	.	4	.	.	.	.	.	.	.	.	1	.	.	.	1	2	.	6	2	1
6. Geckotidae (Geckos), . . 27	4	5	.	1	1	3	.	.	.	2	2	3	.	1	2	.	.	.	4	4	5	11	6	2
7. Iguanidae (Iguanas), . . 55	1	6	1	6	.	.	1	4	2	6	6	14	1	.	1	.	.	5	3	.	22	13	17	3
8. Varanidae (Varans, Monitors, &c.), ... 15	1	4	.	1	.	.	.	.	1	.	.	.	.	.	.	2	1	1	.	1	.	5	7	2
9. Teidae (Teguixins), ... 11	.	.	.	.	.	.	.	.	.	.	6	8	.	.	.	.	.	.	.	.	11	.	.	.
10. Lacertidae (True Lizards), 20	7	5	.	.	.	.	1	.	.	.	1	2	.	.	.	.	.	1	8	5	3	9	2	.
11. Chalcidae (Chalcis, Saurophis, &c.), ... 16	3	.	1	3	.	.	1	1	1	.	2	4	.	.	.	.	.	2	3	1	6	7	.	.
12. Scincidae (Skinks), ... 39	6	5	2	5	.	5	.	2	.	2	1	11	.	1	4	3	.	1	10	3	14	15	7	5
III. OPHIDIA (Serpents), 265 (Containing the Families 13–21.)	11	10	10	18	6	5	2	28	6	24	48	42	5	7	11	12	2	30	15	15	84	50	105	23
IV. AMPHIBIA (Frogs), 120	7	2	.	1	.	.	3	38	1	1	21	56	1	2	6	3	.	39	23	8	74	9	6	7
22. Caeciliadae (Caecilias), . . . 5	.	.	.	.	.	.	.	.	.	.	4	3	.	.	.	.	.	.	.	.	4	.	1	.
23. Ranidae (True Frogs), . . . 81	5	2	.	1	.	.	2	17	.	1	17	53	1	2	6	3	.	17	13	7	70	7	5	7
24. Salamandridae (Tritons and Newts), ... 26	2	.	.	.	.	.	1	15	.	.	.	.	.	.	.	.	.	15	9	1	.	2	.	.
25. Amphiumidae (Amphiuma, &c.), ... 2	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.
26. Proteidae (Proteus, Axolotl, &c.), 6	.	.	.	.	.	.	.	4	1	.	.	.	.	.	.	.	.	5	1	.	.	.	.	.
AMOUNT OF THE SPECIES OF ALL REPTILES, ... 657	48	43	19	39	9	19	9	93	17	43	95	159	9	11	29	22	3	103	73	44	243	143	179	49

The above table shows that the number of species of Reptiles occurring in the countries of the torrid zone is at least double that of the countries of the temperate zone, and that, as in the case of the most of the orders of Mammalia, the exception to this general law is found in the Australian province, which does not contain a third part of the number occurring in the adjoining Tropical province of Asia, nor even as many as are found in Europe. The relative maxima of species are, for the Old World, eighty-four (in Java); and for the New World one hundred and fifty-nine (in Brazil), that is to say, America contains nearly the half of all Reptiles.

In regard to the division of the single orders, we find that the order of the *Tortoises* is most numerous in the United States, in Brazil, and in the Great Sunda Islands. In Africa, the Barbary States contain the greatest number of species, the amount being equal to those inhabiting the whole of Europe, which are almost all found in the countries bordering on the Mediterranean Sea.

Of the two hundred and three species which compose the order of the *Lizards*, by far the greater number occur in the provinces of Africa and South America, each of which contains about one-third; but the relative greatest number of species is found in Brazil, which possesses forty-six, or nearly one-fourth of all the Lizards. To this country the families of the Teguixins, Iguanas, and Skinks are peculiar, and it contains most of the species of Crocodiles. North America possesses, in proportion to the other provinces, as well as to the three other orders, the smallest number of Lizards. In Europe, the greater number of species belongs to the families of the Geckos, True Lizards, and Skinks. Of these together, Italy alone contains seventeen species. In Asia, although the countries of the tropical regions are richer in species than those of the temperate regions, the case is very different in regard to the single families. In Africa the northern countries contain the greatest number of species; the Chameleons, Geckos, Monitors, and Skinks are the characteristic families in this quarter. In Australia and New Guinea the greatest number of species belongs to the Scincidae.

To the most numerous and most important order, that of the *Serpents*, a separate section is devoted, so that they are not treated of in this general view; but, in order to complete the survey, the gross number of their species is quoted in the foregoing table, which shows the very striking result of their division in the two neighbouring islands of Borneo and Java, since in the former not a single species has yet been observed, while the latter contains relatively the greatest number of species of all countries, namely, fifty-six species, or more than one-fifth of all Serpents.

The last and least important order, that of the *Frogs*, is distinguished in its division from the three first orders in this respect, that it occurs in by far the greatest numbers in the New World; for while the Tropical province of America contains seventy-four species, the two corresponding provinces of the Old World have, respectively, only nine and six species; and even these few species generally inhabit the more temperate countries of this province, for on none of the islands of the Asiatic Archipelago has a single frog hitherto been observed. North America and Europe occupy the middle space, between these two extremes. In Europe, the species are very equally distributed.

SECTION I.

DISTRIBUTION OF THE ORDERS AND SOME OF THE GENERA AND SPECIES.

ORDER I.—*Testudines* (Tortoises). The animals of this order are, more than those of any of the others, limited to the countries of the torrid zone. The Marsh Tortoise attains the highest latitude; *Emys Europæa* (common Marsh Tortoise), extends to the parallel of 52° north, in the Prussian provinces of Silesia and Brandenburg, while the northernmost limit in North America is formed by a species of Emys frequenting the River Winnipeg, in 50° north latitude. The southernmost limit is formed by a species of the family of Land Tortoises, *Testudo sulcata* (Furrowed Tortoise), which, according to d'Orbigny, is common in Patagonia. The Marine Tortoises, or Turtles, generally termed *Chelonians*, are found on the shores of all the tropical seas, but chiefly within the parallels of 30° north, and 30° south latitude. To the south they are found in Norfolk Island, latitude 29° south; but in the Northern Hemisphere they reach, as occasional stragglers, a much higher latitude. In the New World, *Sphargis coriacea* (Leathery Tortoise) is found as far north as Massachusetts Bay, latitude 43° north; in the Old World, the same species is frequently met with in the Mediterranean, especially on the northern coast of Africa, and on the shores of Sardinia; it is occasionally captured in the Adriatic Sea, in the River Loire, in Languedoc, Cette, Bretagne, and sometimes on the coast of Cornwall. Once, indeed, a Hawk's-bill Turtle (*Chelonia imbricata*) was caught at Papa Stour, one of the Shetland Islands, in latitude 60° 30′ north; and Fleming, who states this extraordinary case in his excellent "History of British Animals," assigns as the probable cause of its being found there, uncommonly warm seasons, the more or less abundant supply of food, or the prevalence of storms. Perhaps the Gulf Stream may have assisted in its transportation to so high a latitude. The chase of the Hawk's-bill Turtle, which furnishes the horny plates covering the carapace, known in commerce under the name of tortoise-shell, and which affords an important article of trade, is carried on chiefly in two separate regions of the globe. In the Eastern Hemisphere, the principal theatre of this fishery, is in the Molucca Islands, and on the north-western coast of New Guinea, and in the Western Hemisphere, at Haiti, and particularly at Cuba, and among the Cayman Islands. But the produce of the fishery of the Pacific Ocean is so much more valuable than that of the Atlantic, that while the shell procured by the former brings 60s., the latter is reckoned as worth only 46s. per pound weight.

ORDER II.—*Sauria* (Lizards). The first and most important family of this order, that of the Crocodiles, is divided into three groups, which derive their names from the different parts of the globe in which they are found. The Alligators or Caymans are peculiar to America, the True Crocodiles to Africa, and the Gavials to Asia. The Alligators have the widest circle of distribution, since they extend from latitude 31° south, through Paraguay and Brazil, across Central America and the Antilles, through Mexico, Louisiana, Florida, and Georgia, to Carolina, in latitude 32° 30′ north. The African Crocodiles extend from Congo to Senegambia on the west, and Egypt on the east. The common Crocodile of the Nile is distributed over nearly the whole river district, and though it is no longer found in the Delta, it is abundant in the Thebaid, on the Upper Nile and its tributaries, throughout Nubia and Abyssinia. The Asiatic Crocodile extends from the north-west coast of Australia through the Indian Archipelago to Hindustan, where *Gavialis Gangeticus* (Gavial) is found in the Ganges. During the expedition, under Colonel Chesney, in 1835, crocodiles were discovered in the Euphrates River. Of the remaining families, one of the most interesting is that of the Chameleons, the habitat of which, as shown by the map, is exclusively confined to the Old World. One of its species, *Chamæleo Africanus* (Common Chameleon), extends, in the south of Europe, to the southern parts of Spain and Sicily. Some species of the family of Geckos are also inhabitants of the warmer parts of Europe; but of all the families, only the True Lizards and Skinks attain the latitude of Great Britain, where *Lacerta agilis* (Land Lizard) extends to Scotland and Ireland. This species is common in France, and in the middle districts of Europe, but it is rare in Italy. Of the Skinks, *Anguis fragilis* (Blind or Slow-Worm) is an inhabitant of Great Britain.

ORDER IV.—*Batrachia* or *Amphibia* (Frogs). We have already referred generally to the extension of the animals of this order. The beautiful little animal *Hyla viridis* (green Tree-Frog), is found in all the countries of middle and southern Europe and northern Africa, to the Island of Teneriffe; it occurs also in Japan; it has never been observed in Great Britain, though it is not uncommon in France. Of the Reptiles belonging to Great Britain, the table shows that the greater number, namely, eight species, belong to this order.

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[1] See American Journal of Science, 1843-44. No. 46.

SECTION II.

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF OPHIDIA *(SERPENTS)* ACCORDING TO SCHLEGEL.

General Remarks on Distribution.—The geographical distribution of Serpents is subject to nearly the same laws as that of other Reptiles; their number increases toward the torrid zone, while comparatively few are found in cold regions. They do not appear to advance so far northwards as Lizards, and Batrachians, which are probably among the number of the most widely distributed Reptiles.

One of the most curious facts in the distribution of Serpents, viewed in relation to different parts of the globe, is their total absence in the numerous isles of the Pacific Ocean; a phenomenon the more remarkable, since the neighbouring isles, forming the great Indian Archipelago, belong to those regions of the earth most abounding in Serpents. Another interesting fact is, that the Serpents, and, indeed, all the Reptiles of America, are specifically different from those of the Old World; while, on the other hand, a great many birds and several mammiferous animals of North America, are precisely the same as those of Europe and a great part of Asia. This is the more singular, because many of our Reptiles are found in all the countries of Temperate Asia to Japan, often without presenting the slightest difference. South America produces, in general, different species from North America, although several of them are perfectly identical in these two vast regions. Some species of the first region also inhabit the Antilles, and are found even in the southern countries of the United States, where they occasionally form climatal varieties; other species, common throughout North America, are distributed in Mexico, and are also met with in the Antilles. America in general, especially in its equatorial regions, is nearly as rich in Serpents as the East Indies. It is very different with Australia, which seems to be inhabited by only a small number of Ophidians; forming, with perhaps the exception of some of its northern parts, species peculiar to that vast island. The Serpents of Japan belong, without exception, to peculiar species, which have not yet been observed in any other spot on the globe. The numerous isles of the great Indian Archipelago often contain species entirely similar, and even absolutely identical, with those which occur in Malacca, Bengal, the continent of India, and Ceylon. Sometimes, however, the species in these different places present differences more or less marked, and occasion the establishment of local varieties. Judging from the small number of its productions known to us, the Island of Madagascar appears to have a fauna of its own. Africa is not rich in Ophidians. The southern part of that vast peninsula produces species different from those of Europe and of other parts of the globe; and these same species are often spread over the whole of intertropical Africa, and are found extending even to the northern parts of that continent; but besides a few peculiar species, these last named countries produce several others, which inhabit, at the same time, almost all the countries bordering on the Mediterranean, even to Syria, and consequently a great part of Europe. Most of the European Serpents are spread over a great part of Temperate Asia—a region which appears to produce only a small number of peculiar species.

The geographical distribution of genera, or of families considered as representing the different principal forms, is not a less curious study than that of the species. We see at once that the Venomous Serpents are distributed, with the exception, perhaps, of some islands, in every country inhabited by Serpents in general. These dangerous Reptiles do not appear to dread cold, for they are often found as far to the north as the innocuous species; but their number is much more limited than that of the latter; for of the two hundred and sixty-five known species of Ophidians only fifty-eight are venomous, so that the proportion of the venomous to the innocuous is nearly as 1 to 4. We shall afterwards find, however, that this proportion is not the same in all the countries of the globe, and that the number of Venomous Serpents, at least that of individuals, appears to be more considerable in barren and sterile countries, where that of the innocuous seems to diminish. Africa and Australia afford examples of this; in the former continent, the species of known Innocuous Serpents are in the ratio of 2 or 3 to 1, whilst nearly the reverse of this occurs in Australia, where, of the ten known species, seven are venomous. The number of individuals is much more limited in Venomous Serpents, which, with the exception of Sea Snakes, live almost always isolated, and never multiply so as to become abundant, except in very favourable circumstances, as in the case of the *Trigonocephalus lanceolatus* in the French Antilles, or the *Vipera ammodytes* in Dalmatia. Venomous Serpents, then, belong generally to the rare class, and are perhaps much more rare than is generally believed; either because the number of individuals is often very limited, or because (thanks to their habits) they more readily escape the observation of mankind.

Except the anomalous species which compose the family of *Tortrix*, there does not exist one genus of Serpent which is at the same time spread over all parts of the globe inhabited by Reptiles; and this curious fact will serve to demonstrate how intimate is the relation which subsists between the organization of beings and the nature of the places they inhabit. The True Adders (*Coluber*), for example, which are destined to inhabit woody or marshy countries, covered with abundant vegetation, have not yet been observed in Australia; and are so rare in southern Africa, that only a single species is known; and this differs in several points of structure, from other Colubri, in so far that it approaches to those Serpents that prefer to inhabit desert or sandy countries. We may apply almost the same observations to the genus *Coronella*—Serpents which inhabit marshy plains or heathy furze coverts, and of which no species is known to exist in Australia, while those of Southern Africa differ from the typical species. The *Tree Serpents* are especially peculiar to equatorial countries; but as they inhabit vast forests or well wooded regions, they are not found in countries where these conditions, necessary to their existence, are not met with. Hence, probably, the reason why these Serpents have not been found in the greater part of Australia, and that Southern Africa supports only a single species of this family, which, too, is anomalous, approaching to the genus *Coluber*. The three genera which compose the family of Tree Serpents, are found both in the Old and the New World; but it must be observed, that the *Dipsas* of America never attain that great size which is remarked in most of the Indian species, and that the *Dryiophis* of the New World form a true geographical division in this, that they have the dentary system, and the muzzle less developed, and that the pupil of the eye is orbicular.

The Fresh-water Serpents which are comprised in the two genera *Tropidonotus* and *Homalopsis*, are abundant in countries rich in lakes, or watered by numerous rivers; hence it is that these animals are common in Asia, in America, and even in Europe; that they are probably not met with at all in Australia; and that they are rare in Africa: for there exists only a single species of *Tropidonotus* in the southern part of that continent, and even it presents an organization wholly anomalous. The Homalopsis even, which are peculiarly Fresh-water Snakes, and essentially aquatic, and which belong to warm countries, have not been observed either in Australia or in Africa, while they abound in both Americas; they even replace the *Tropidonotus* in South America, which has not yet been observed in that vast peninsula.

The geographical distribution of *Boas* presents several facts worthy of notice. They are peculiar to hot climates. The *True Boas* belong exclusively to South America; and they are replaced in the Old World by the *Pythons*. There are in India, however, several Serpents quite analogous to the Boas, but much smaller; of these there exists, in the whole Western Hemisphere, only one representative, in the Island of Cuba. The *Acrochordus* are exclusively limited to the East Indies.

Among Venomous Serpents, only the genus *Viper*, and perhaps some of the genus *Crotalus*, advance northwards to the temperate and cold regions; whilst the other genera appear to be specially destined to inhabit intertropical countries. Of the Colubriform Venomous Serpents, the genus *Elaps* alone is found both in the Old and the New World; yet the Elaps of America forms a small geographical group, distinguished by the system of colouring, and by some minor details of form. Those of India are striped longitudinally, instead of being annulated with red and black; those of Australia may be considered as forming anomalous species. The *Bungari* are peculiar to the East Indies, where also the *Najas* are found, although the latter appear to prefer arid or sandy plains—which explains their predominance in Africa and Australia. We are not yet enabled to explain the phenomenon that *Sea Serpents* are exclusively found in the Indian Seas, from the coast of Malabar to the Pacific Ocean. Lastly, it remains to add some curious observations on *Venomous Serpents, properly so called*. Of the three genera of which this family is composed, the *Vipera* is peculiar to the Old World, whilst the *Crotalus* is only found in America, where it replaces the former; but the *Trigonocephalus* is found in both. These last Reptiles, which inhabit wooded countries and extensive forests, are, on this account, not found in Africa or Australia, where they are replaced by the Vipers; but it must be observed that the Viper of Australia forms an anomalous species, whilst those which inhabit Europe differ equally from the typical species, and approach the Trigonocephalus.

TABLE SHOWING THE DIVISION OF *SERPENTS* IN SCHLEGEL'S ZOOLOGICAL PROVINCES AND REGIONS.

FAMILIES and Genera of SERPENTS, with the Number of their Species.		Zoological Provinces and Regions, indicating the degree of mean latitude in which they are situated.																												
		Europe.			Africa.				Asia.						Oceania.									America.						
		Western E.	Southern E.	Central E.	Northern Af.	Western Af.	Southern Af.	Madagascar.	Western As.	East Indies.	Ceylon.	Bengal.	Eastern As.	Japan.	Mariana Is.	Philippine Is.	Amboina.	Sumatra.	Java.	Celebes.	Timor.	New Guinea.	Australia.	Chile.	Paraguay.	Brazil.	Guyana.	Antilles.	Mexico.	United States.
		47°	41°	50°	33°	7°	33°	20°	42°	15°	7°	25°	30°	35°	15°	13°	5°	0°	8°	3°	9°	6°	25°	34°	23°	15°	4°	15°	29°	38°
		Number of the Species.																												
INNOCUOUS SERPENTS,	**207**	**5**	**13**	**4**	**11**	**9**	**10**	**10**	**7**	**19**	**10**	**20**	**8**	**5**	**2**	**6**	**8**	**18**	**47**	**12**	**7**	**9**	**4**	**7**	**4**	**37**	**41**	**22**	**4**	**24**
I. Burrowing Serpents.																														
1. Tortrix,	7	.	1	.	1	.	.	.	1	2	1	1	.	.	.	.	.	1	2	2	.	1	1	1	.	.	1		.	.
II. Vermiform Serpents.																														
2. Calamaria,	18	.	.	.	.	1	1	.	1	.	2	.	.	.	.	2	.	2	5	1	1	.	1	2	.	2	2	2	.	4
III. Terrestrial Serpents.																														
3. Coronella,	14	.	1	1	1	.	4	.	.	1	.	1	.	.	.	.	.	1	1	.	.	.	.	2	1	3	3	2	1	2
4. Xenodon,	8	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	3	2	.	.	.
5. Heterodon,	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	1	1	2
6. Lycodon,	13	.	.	.	.	2	1	.	.	3	1	2	.	.	.	.	1	.	2	.	1	1	.	.	1	3	2	1	.	1
7. Coluber,	27	2	5	1	4	.	1	1	1	2	.	1	1	3	.	.	.	3	4	1	1	.	.	.	.	4	5	1	.	3
8. Herpetodryas,	19	.	.	.	.	.	.	2	.	.	.	1	.	.	.	.	.	.	3	2	.	.	.	.	1	6	7	2	.	5
9. Psammophis,	8	1	2	.	2	2	1	2	2	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	1	.	.
IV. Tree Snakes.																														
10. Dendrophis,	10	.	.	.	.	3	1	.	.	2	2	2	2	.	.	1	2	3	3	.	.	1	1	1	.	1	2	2	.	1
11. Dryiophis,	7	.	.	.	.	.	.	1	.	1	.	2	1	.	1	.	.	1	2	1	.	.	.	.	.	1	3	2	1	.
12. Dipsas,	25	.	1	.	1	.	.	2	1	1	1	2	.	.	.	.	1	2	7	4	.	1	.	.	1	4	7	1	.	.
V. Fresh-Water Serpents.																														
13. Tropidonotus,	19	1	2	2	2	.	1	1	1	3	2	4	2	2	1	3	.	1	6	1	.	1	.	.	.	.	.	3	1	3
14. Homalopsis,	14	.	.	.	.	.	.	.	.	1	.	2	.	.	.	.	1	1	5	.	2	1	.	.	.	3	2	1	.	3
VI. Boaform Serpents.																														
15. Boa,	9	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	5	5	3	.	.
16. Python,	4	.	.	.	.	1	.	.	.	1	1	1	2	.	.	.	2	2	2	.	1	1	1	.	.	.	.	.	.	.
17. Acrochordus,	2	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	2	.	1	1	.	.	.	.	.	.	.	.
VENOMOUS SERPENTS,	**58**	.	**2**	**1**	**4**	**1**	**8**	.	**1**	**15**	**13**	**11**	**6**	**1**	.	**3**	**3**	**8**	**9**	**4**	**2**	**3**	**7**	.	**1**	**5**	**7**	**2**	**2**	**4**
VII. Colubriform Venomous Serpents.																														
18. Elaps,	12	.	.	.	.	.	1	.	.	1	.	.	1	.	.	1	.	2	2	.	.	1	2	.	.	1	3	1	1	1
19. Bungarus,	2	.	.	.	.	.	.	.	.	2	2	2	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
20. Naja,	10	.	.	.	1	1	4	.	.	2	1	1	1	.	.	1	.	2	2	.	.	.	2	.	.	.	.	.	.	.
VIII. Sea Serpents.																														
21. Hydrophis,	7	.	.	.	.	.	.	.	.	7	7	7	4	.	.	.	3	2	1	3	1	2	2	.	.	.	.	.	.	.
IX. Venomous Serpents, properly so called.																														
22. Trigonocephalus,	13	.	.	.	.	.	.	.	1	1	2	.	.	1	.	1	.	2	2	1	1	.	.	.	1	2	2	1	.	1
23. Crotalus,	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	1	2
24. Vipera,	10	.	2	1	3	.	3	.	.	2	1	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Amount of the Species of all Serpents,	**265**	**5**	**15**	**5**	**15**	**10**	**18**	**10**	**8**	**34**	**23**	**31**	**14**	**6**	**2**	**9**	**11**	**26**	**56**	**16**	**9**	**12**	**11**	**7**	**5**	**42**	**48**	**24**	**6**	**28**

The foregoing table precludes the necessity for any detailed account of the division and intensity of Serpents in the different countries of the globe. It may be useful, however, to point out some of the more important facts which it exhibits. On examining the column headed Europe, for example, it will be found that in this quarter of the globe many of the genera are entirely wanting—that it supports neither Calamars, nor Heterodons, nor Lycodons; that the True Tree-Snakes are not found there, nor even the Herpetodryas; that there exists in it neither the Homalopsis nor the Boa; that the families of Colubriform Venomous Serpents and Sea Serpents are never met with; and in short, that the true Venomous Snakes have no other representatives than several species of the genus Vipera.

On comparing the other columns, it will be found that the Island of Java contains the greatest number of species in any of the provinces; that in Australia, by far the greater number of species belong to the Venomous Serpents, &c.; and that, as in the case of the Carnivora among Mammalia, the greatest number, and the most destructive species of reptiles are found in tropical countries, where their presence is required to keep in check the excessive productiveness of other animals.

The above is an abridgment of the "Essai sur la Distribution Géographique des Ophidiens" in Schlegel's work,[1] to which we must refer the student of Ophiology. There is an excellent translation of the general portion of Schlegel's Essay, by Professor Trail, Edinburgh, 1843.

PERPENDICULAR DISTRIBUTION OF REPTILES.

Tropical Province.—As shown in the diagram on the map, Crocodiles and Boas are found on the Andes of Quito, at an elevation of 3,000 feet. *Siredon pisciformis* (Axolotl), a native of Mexico, is found at an elevation of at least 8,000 feet. Temperate Province.—In the Alps, *Rana temporaria* occurs in the vicinity of the snow line; *Rana alpina*, above 4,500 feet; *Triton alpestris*, 5,400 feet; *Vipera berus*, and *Vipera cherzea*, 5,300 feet; *Lacerta montana*, 4,500; and *Anguis fragilis* nearly as high as 6,000 feet. In the Pyrenees, *Rana temporaria* ascends to a height of 7,700 feet.

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[1] Essai sur la Physiognomie des Serpens, par H. Schlegel &c. La Haye: 1837

ZOOLOGICAL GEOGRAPHY.

DISTRIBUTION OF MARINE LIFE,

By PROFESSOR EDWARD FORBES, F.R.S., &c., President of the Geological Society.

EXPLANATION OF THE MAP.

In this Map an endeavour is made to lay down and generalise the leading facts of the distribution of Marine creatures, to define the provinces of Marine life, and to show their natural and representative relations.

The instances inserted in the Map are selected from the classes of Fishes, Molluscs, and Radiata. What is true of these will hold good in the main with articulate animals, and with marine plants. The examples shown are all either genera peculiar to, or remarkably developed within, a province, or species highly characteristic of it. Of course, with the scale employed, the number of examples required to be limited, otherwise confusion instead of clearness would have resulted.

In the present state of our knowledge, many of the arrangements in this Map can be regarded as only provisional and conjectural. But, in the main, I believe the arrangement and succession of the provinces will prove to be true. Many of them, indeed, are laid down from minute and abundant data.

PROVINCES OF MARINE LIFE.

As there are provinces of animal and vegetable life on the land, so there are also in the sea. The character of a marine province is marked by the entire assemblage of animals and plants constituting its population; a considerable proportion, in most cases, being peculiar to the province, and a still larger number of species having their areas of maximum development within it. Part of the population of every province is constituted of colonists from neighbouring regions, and in some instances from the descendants of species which rather belonged to the provinces of a former geological epoch than to the fauna of the present time. The extension of a province in a great measure depends on the nature of the sea-coast, on the kind of sea-bed, on the direction and spread of currents, and on the depth of the sea. The longitudinal dimensions of a province correspond with the breadth of the homoiozoic belt in which it lies, and its latitudinal dimensions on the extension of conditions of depth and sea-bed capable of supporting animal and vegetable life.

The several provinces vary greatly in extent, some being very small, some very large. But though not equally important in a geographical point of view, their inequality of extension is not opposed to their being of equal natural history importance; moreover, we must not always judge of the extension of a province by its present dimensions, since, when traced back in time, provinces now of small extent may have had a wide spread, and *vice versa*.

I.—ARCTIC PROVINCE.

The area of this region corresponds exactly with that of the north polar homoiozoic belt; for all round the pole we find a uniform, or nearly uniform, marine fauna; the animals of Behring Strait being, in the mass, specifically identical with those of the Greenland and icy seas. Dulness of colour, paucity in the number of species included in the genera, comparative abundance of individuals, and a tendency to excessive variation, probably due to the effect of the influence of fresh water derived from the ice, are characteristic features of the arctic fauna. Its southernmost extension is on the coast of Boreal America. There we find it mingling with and passing into a boreal fauna. On the European coast, however, it is nearly confined to the shores of the Icy Sea. The authorities for this province are Scoresby, Phipps, Ross, and other arctic voyagers, for its general features; Otho Fabricius, Richardson, Müller, Sabine, Bayfield, and Kroyer, for the fauna of the American arctic, and polar seas; Middendorff and Von Baer for the icy sea, and the region of Behring Strait. Original information, derived from the researches conducted by Captain Kellett, R.N., letters from Mr Harry Goodsir, one of the companions of Franklin, and information communicated by Dr Sutherland, have contributed data for the laying down of this region.

II.—BOREAL PROVINCE.

The west coast of Scandinavia, including all Norway from the Lofoden Isles southwards, and excluding the coasts of Sweden and Denmark, constitutes the European boundary; whilst the area between Newfoundland and Cape Cod, or a little to the south, represents its American extent, or *Bostonian* sub-region. Iceland, unless a small portion of its north-west coast be excluded, falls within it. It is in great part a deep-sea region, and the field of various fisheries, chiefly of the cod tribe. The chief authorities for this province are—for its animals, O. F. Müller, Nillson, Sars, Loven, Duben, Koren, and Gould; and for its sea-plants, Agardh and Harvey. It has been well worked, especially on the European side.

III.—CELTIC PROVINCE.

This area is confined to the European side of the Atlantic; it embraces the seas around the British Isles from south of the Zetland Isles to the northern limits of the Bay of Biscay. It includes the shores of Denmark and Bohus-len (Sweden); and the Baltic Sea can be regarded zoologically and botanically, only as a subordinate arm of it. Its population is much mixed with boreal and Lusitanian colonists. Within it are not a few arctic or rather boreal outliers. This is the great field of the herring fisheries. It has been thoroughly investigated, and the number of works and memoirs on all departments of its marine fauna and flora is far too great to permit us to state them at length. The naturalists of Britain, Denmark, and Sweden have been the chief and indefatigable explorers of this important area.

IV.—LUSITANIAN PROVINCE.

This embraces the Bay of Biscay, the seas of the west and north coast of Spain and of Portugal, and those of the north-west coast of Africa as far south as the Canary Islands. On many of its details we are as yet imperfectly informed. Westward it may be said to extend to the Azores. My authorities for detail are—Collard des Cherres for the mollusca of its northernmost boundary; MacAndrew for those of the coast of Spain and Portugal, also for those of Madeira and Canaries, very recently explored by my energetic friend, (1852;) Lowe for the fishes of the southern portion of the province; D'Orbigny for the fauna of the Canaries; also private information derived from collections made by Mr Smith of Jordanhill. Pilchard fisheries distinguish the northern half of this province.

V.—MEDITERRANEAN PROVINCE.

This region includes the whole of the Mediterranean Sea and the greater part of the Black Sea. It has an abundant fauna and flora, but few peculiarities, and is possibly only a colony of the Lusitanian area. Tunny, coral, and sponge fisheries are characteristic of it. Its fauna is very uniform throughout, but diminishes in amount of species as we proceed from west to east. It has been ably investigated. To name a tithe of the writers upon its natural history would be to give a long catalogue. For summaries of its fishes and molluscs, the writings of the Prince of Canino and of Phillippi, and my own Ægean catalogues, may be taken. Middendorff has given full lists of the Black Sea molluscs. Agardh has catalogued the algæ.

The Aralo-Caspian may be mentioned here as an outlying and exceptional province; it is the fragment of a larger and more ancient area. For its fauna, consult the writings of Eichwald and Middendorff.

VI.—WEST AFRICAN PROVINCE.

This region includes the eastern portion of the intertropical Atlantic, with a slight extension beyond the tropics in each hemisphere. It is in great part laid down hypothetically, for we can scarcely speak with confidence upon the population of the area between the Bight of Benin and the commencement of the South African region. The researches of Adanson in Senegal, and the collections made by various expeditions to the Guinea and neighbouring coasts, have furnished the best part of our information on its northern portion. A systematic explanation of the marine natural history of the Cape de Verde Isles would probably be one of the best methods of obtaining a sound basis of information. St Helena exhibits some peculiarities which seem to indicate an ancient affinity between the West African and Caribbean faunas; but as yet our acquaintance with its marine fauna is exceedingly fragmentary.

VII.—SOUTH AFRICAN PROVINCE.

Its extent and limits appear to be determined by temperature, and still more by the set and turning-places of the currents around the Cape of Good Hope. The result is the presence of a highly peculiar and characteristic marine population. The labours of Krauss have formed the chief basis of our knowledge of the molluscan fauna of this region. The collections made during the voyage of the Rattlesnake, and communications from Dr Stanger, now Surveyor-general of Port-Natal, have been valuable aids.

VIII.—INDO-PACIFIC PROVINCE.

This is the greatest of all the marine regions. I regard it as constituting but a single division, because all explorations go to show that throughout its area there is a basis, as it were, of identical species, giving a uniform character to its fauna. It is the realm of reef-building corals, and of the wondrously beautiful assemblage of animals, vertebrate and invertebrate, that live among them, or prey upon them. The brightest and most definite arrangements of colour are here displayed. It is the seat of the maximum development of the majority of marine genera. It has but few relations of identity with other provinces. The Red Sea and Persian Gulf are its offsets. Latitudinally, it extends from the east coast of Africa to the outermost limits of Polynesia. Longitudinally, it reaches from Port Natal, where its fauna mingles with the South African, to Suez, and from Sandy Cape, on the east coast of New Holland, where its fauna comes in contact with the typical Australian, to (probably) the Yellow Sea. Its strictest and most typical portion is that included within the southern and northern limits of coral reefs. *Madreporidæ* and *Astreidæ* characterise the central portions of this division, whilst *Poritidæ* prevail towards the circumference.

This region has been the scene of numerous original researches. Ruppell and Ehrenberg may be cited as leading authorities regarding the Red Sea, Richardson and Lesson for the fishes of the region generally, Darwin and Dana for the corals, and the numerous scientific memoirs appended to English and French surveying voyages for abundant details respecting all departments of its marine natural history.

IX.—AUSTRALIAN PROVINCE.

The seas of extra-tropical Australia are peopled by a peculiar assemblage of creatures, among which are many remarkable generic types not met with elsewhere. The seas around the greater part of the New Zealand islands may be included in the same category. The reports of Richardson on Australian fishes, and the collections of Australian invertebrata made by Macgillivray and other voyage-naturalists, enable us to lay down this province with confidence.

X.—JAPONIAN PROVINCE.

This is mapped on imperfect information; nevertheless, what is known, especially through the researches of Dutch naturalists and the reports of Richardson, warrants our colouring the space marked upon our map without much hesitation. Its northern boundaries are undetermined; but there are indications of an intervening fauna between the Japonian and that of the Sea of Ochotz. This intermediate province is delineated hypothetically, and named—

XI.—MANTCHOURIAN.

XII.—OCHOTZIAN.

The researches of Middendorff have made well known at least the Molluscan fauna of the Sea of Ochotz, and the existence of a peculiar province there, bordering upon the Arctic; which last appears to have an extension around the Kamtschatkan peninsula.

XIII.—SITCHIAN.

This province represents the Ochotzian on the American side of the Pacific. Eschscholtz and Middendorff have furnished the chief information concerning it. Its molluscan fauna is considerably mingled with Arctic faunas, indicating the influence of polar currents hereabouts. It appears to correspond with the Boreal province of the North Atlantic.

XIV.—OREGONIAN.

Of this region, and of the next—

XV.—CALIFORNIAN,

We may, before long, expect more perfect details. That their extent as laid down upon the Map is near about the mark, I have little doubt; and have been chiefly guided in determining their value by the collections made by Captains Kellett and Wood.

XVI.—PANAMIAN.

This is the representative of the tropical regions of the Atlantic and of the Indo-Pacific; but on account of its limitation through the influence of the cold antarctic currents pouring along the west coast of South America, it has neither their extent nor their importance, though peopled by a fauna and flora in many respects reminding us of those of the great regions just mentioned. The Panamian province has been delineated chiefly on the strength of information obtained after examination of its molluscs, of which an abundant collection is contained in the cabinet of Mr Cuming. It has very recently been explored by Professor Adams.

XVII.—PERUVIAN PROVINCE.

The extension northwards, nearly or quite to the equator, of this region, is due to the modifying influence of cold currents from the south. Its extreme boundary may be marked at the Galapagos islands, though on the main coast it does not range so high. Its extent has been laid down chiefly through the very complete knowledge of its molluscan fauna, the result of the researches of Hugh Cuming; whence, also, the principal data for constituting the—

XVIII.—ARAUCANIAN PROVINCE.

XIX.—FUEGIAN PROVINCE.

The observations and collections made by Darwin, during the voyage of the Beagle, go to show not only the distinction of this natural history region, but also its representative character when compared with the Boreal province in the northern hemisphere.

XX.—ANTARCTIC PROVINCE.

Corresponding to the Arctic province and representative; forming, like it, the circum-polar belt.

XXI.—EAST PATAGONIAN, AND

XXII.—URUGAVIAN PROVINCE.

Of these regions we require many more details, and can lay them down only approximately—chiefly from the data supplied by Alcide D'Orbigny, in his great work on South America.

XXIII.—CARIBBEAN PROVINCE.

In the West Indian Archipelago are concentrated all the orographical and hydrographical conditions calculated for the development of an extensive marine fauna and flora. Here is the only coral-reef region in the Atlantic, inhabited by mollusca, articulata, and radiata, strikingly representative of, but entirely distinct from, those of the Indo-Pacific. The differences between this assemblage and those peopling the Gulf of Mexico on the one hand, and the extensive shores of Brazil on the other, although at first glance apparently indicative of sub-regions, or even distinct provinces, appear, on closer inquiry, to be only such as would necessarily result from differences in the conditions of sea-bottom. The number of species that ranges from Florida to Rio is very considerable.

XXIV.—CAROLINIAN PROVINCE.

XXV.—VIRGINIAN PROVINCE.

These two areas, limited although they are, appear to represent the Lusitanian and Celtic regions of the eastern side of the North Atlantic. Possibly the latter should be restricted to still narrower bounds than those indicated in the map.

I have attempted to indicate the littoral relations of all the provinces by marking the distribution of the leading species of the molluscous genera *Littorina* and *Haliotis*. If, for example, we regard the western coast of America, we see there a complete succession of species of *Littorina* representing each other along the whole Pacific coast of the New World. A similar representative succession of species of *Haliotis* may be traced on the other side of the Pacific, from Van Diemen's Land to Behring Strait. The majority of provinces are seen to be characterised by their peculiar types of the littoral molluscs; and could we lay down the distribution of other littoral creatures, we should find that what is true with regard to the genera and species cited, holds true with the great majority of their companions. There are considerable areas whence members of the genera selected are absent. These may usually be regarded as long stretches of coast, upon which no hard rock appears. Such extensive reaches of sandy shore and sea-bed are apt to be barren in animal and vegetable life, and to play the part of deserts in the sea, dividing one fauna or flora from another, and often preventing any mingling of their species, such as invariably happens when two prolific provinces come into contact at their extreme bounds.

As many species of animals and plants have far greater capacity for enduring varying conditions than others, these favoured forms have, in the course of long ages, spread over much wider areas than their companions; and some—mostly species which geological research has traced far back into the tertiary epoch—are almost cosmopolitan. To indicate the extent to which species derived from one fauna may mingle with others, even very distant, a series of arrows is delineated on the map, marking the direction of diffusion, and, by means of cross-bars upon their shafts, the original centres from which these cosmopolitan types have been derived. Since, too, numerous living creatures can trace their pedigree into geological epochs when the geographical arrangements of the world's surface were considerably different from what they now are, it not unfrequently happens that we may detect the influence of an ancient distributive arrangement in the midst of a modern province. These indications are noted by means of arrows with peculiar vanes. As an instance, the probable ancient connection of the Mediterranean and Indo-Pacific provinces is marked by the arrow crossing the Isthmus of Suez.

HOMOIOZOIC BELTS.

The faunas and floras of regions, whether terrestrial or aquatic, placed under similar physical, chiefly climatal, conditions, bear a striking resemblance to each other, and exhibit a *facies* common to all enjoying an existence in the same medium. In proximate provinces this likeness is partly maintained by identity and partly by affinity. In distant provinces it is oftener dependent on analogy, and exhibits what is called *representation*. This may be manifest either between provinces under the same latitudinal parallel, or between those that are placed under similar general conditions in the northern and southern hemispheres.

Latitudinally several provinces may be included within the same belt; but longitudinally one only occupies its dimension. The northern and southern limits of a province, therefore, correspond with the line of separation between two Homoiozoic belts.

In the Map, the provinces of marine life are laid down according to the knowledge we possess of the distribution of species. The lines bounding these provinces latitudinally are connected together across the land by lines which, in the main, correspond with the great features of the arrangement of terrestrial vegetation and animal life. For the most part, the lines on land are drawn in accordance with the isothermal of the month in which the greatest development of animal and vegetable life, taken together, is manifested within the region. By "greatest development," in this instance, is meant the maximum of vivacity, as exhibited in the number of species of vertebrata and articulata out and active at the same time, and of plants in full bloom. The activity of the animal and vegetable kingdoms in this sense will be co-equal.

The bounding lines of Homoiozoic belts are climatal lines; but they are not laid down upon climatal considerations only, but rather empirically, according to our knowledge of the facts of the distribution, which facts, as might *a priori* be expected, accord, with slight exceptions, with climatal arrangements.

In these climatal arrangements we see some of the most important influences determinative of the extent of zoological and botanical provinces.

The boundaries of Homoiozoic belts are not straight parallels of latitude, but undulating lines. They are expressed so diagramatically; but it must be understood that in many, though not in all instances, provinces blend together at their margins.

The two boundary lines of any one belt are not necessarily parallel to each other, or equidistant; nor are they parallel with those of other belts.

The undulations of the boundary-lines of the belts, so far as marine provinces are concerned, (and to a great extent also with terrestrial provinces,) are due to the climatal influence of the warm and cold currents of the ocean.

I distinguish nine Homoiozoic belts, one of which is central and equatorial; and the other eight are, four in the northern and four in the southern hemisphere. They are mutually representative.—I name the belts as follows, commencing with the northernmost:—

I.—NORTH POLAR HOMOIOZOIC BELT.

This corresponds with the first or Arctic province, so far as the sea is concerned, and includes that marine province only. It is the region surrounding the North Pole; and the undulations of its southern boundary are determined mainly by the direction and flow of cold arctic currents. Its *maximum* breadth is between the Pole and the Gulf of St Lawrence; its *minimum* extension between the Pole and the Lofoden Isles near the extreme north of Scandinavia. On land, its southern limit corresponds in a great part, though not throughout, with the northern limit of forests. The isotherm of 54° 5′ in the month of June, (as described on Dove's maps, from which all the isotherms hereafter mentioned are taken,) corresponds very nearly with it.

II.—NORTH CIRCUMPOLAR HOMOIOZOIC BELT.

Three marine provinces are included in this band,—viz., the Boreal, the Sitchian, and the Ochotzian. They are strictly representative of each other—any elements of identity between the first and the two others being derived from the Arctic province. This belt is narrow. It attains its maximum breadth on the coast of Norway, in the region where the first belt recedes most. This is probably due to the feeble but effectual influence of warm currents flowing from the south. On land, its equatorial limits, (exclusive of the British area,) correspond in great part with the course of the isotherm of 59° in the month of June.

III.—NORTHERN NEUTRAL HOMOIOZOIC BELT.

Four marine provinces—the Celtic and Virginian in the Atlantic, the Mantchourian and Oregonian in the Pacific, are included within this band. The Celtic, owing to the influence of the Gulf stream, is the widest. The faunas of all these provinces are much mixed with those of neighbouring areas. The Celtic and Virginian are mutually representative, as are probably the Mantchourian and Oregonian. On land its equatorial limits correspond in the main with the isotherms of 63° in June, and 68° in July.

IV.—NORTHERN CIRCUMCENTRAL HOMOIOZOIC BELT.

Five marine provinces—viz. the Lusitanian, Carolinian, Mediterranean, Japonian, and Californian, are included within this band, as well as the supplementary province of the Aralo-Caspian. It is widest in the Lusitanian province, this extension being due to warm currents flowing northwards towards the British Channel. It is narrowest on the coast of the United States. Its equatorial limit on land corresponds with the isotherm of 68° in May.

V.—CENTRAL HOMOIOZOIC BELT.

This vast Equatorial band includes the largest of marine provinces, the Indo-Pacific; also the great West-African and Caribbean areas and the Panamian, where its dimensions are narrowest, the cold currents from the south causing its boundary to take an inward curve.

VI.—SOUTHERN CIRCUMCENTRAL HOMOIOZOIC BELT.

This band includes the Peruvian, Urugavian, South African, and Australian marine provinces. It is chiefly occupied by sea. The faunas of these four provinces will probably be found very strictly representative, and, so far as known, have very few elements of identity to link them by species in common. This belt represents strikingly its corresponding zone in the northern hemisphere. On land its equatorial limit appears to correspond, in the main, with the isotherm of 68° in October; but that line, as drawn by Dove, is not in exact accordance with its marine boundary.

VII.—SOUTHERN NEUTRAL HOMOIOZOIC BELT.

We can trace this zoologically at present only in the marine provinces Araucanian and East Patagonian. The January isotherm of 59° appears to accord with its probable equatorial limit.

VIII.—SOUTHERN CIRCUMPOLAR HOMOIOZOIC BELT.

The Fuegian province is the only one distinguished as belonging to this band. Its equatorial limit accords with the December isotherm of 50°.

IX.—SOUTHERN POLAR HOMOIOZOIC BELT.

This consists of the Antarctic province. As drawn upon the Map, its equatorial limit coincides with the December isotherm of 41°.

In delineating the Homoiozoic belts, a uniform system of colouring has been employed. The marine provinces of the Central Belt are *yellow* or *orange*; those of the Circumcentral Belts, *pink*; those of the Neutral Belts, *green*; those of the Circumpolar Belts, *purple*; those of the Polar Belts, *blue*. Their *representation* is indicated by similar colours.

DIAGRAM OF ZONES OF DEPTH.

In this table the vertical divisions are occupied with the names of some of the most characteristic marine animals and plants of the several bathymetrical zones in those provinces respecting which we have considerable information. The horizontal divisions represent the zones themselves, arranged in descending order. The column of fathoms gives the mean extent of the several zones. The entire table is a diagram, and not drawn to scale.

I. LITTORAL ZONE.

Everywhere this belt, which occupies the space between high and low water-mark, however great, or however small the fall of the tide, is inhabited, whether the ground is hard or rocky, by gasteropodous molluscs of the genus *Littorina*, and by species of the whelk *Purpura*. In the Arctic and Boreal Seas, *Littorina rudis* and *obtusata*, *Acmæa testudinalis*, and *Purpura lapillus* are the characteristic testacea. *Fucus vesiculosus* is the dominant sea-weed. In the Celtic Seas the features of the subdivisions of this zone are strongly marked both by plants and animals, as shown in the following Table:—

1. Uppermost Sub-region, . .	Animals—*Littorina rudis* and *neritoides*. *Balani*. Plant—*Fucus canaliculatus*.
2. Second Sub-region, . . .	Animals—*Balani*, *Patella vulgata*, *Mytilus edulis*. Plant—*Lichina*.
3. Third Sub-region, . . .	Animals—*Balani*, *Littorina littorea*, *Purpura lapillus*, *Trochus umbilicatus* (local), *Trochus crassus* (local), *Actinea mesembryanthemum*, *Spirorbis*, *Kellia rubra*. Plants—*Fucus vesiculosus*, and *nodosus*. *Corallina officinalis*.
4. Fourth Sub-region, . .	Animals—*Littorina littoralis*, *Acmæa testudinalis* (local), *Trochus cinerarius*, *Patella* and *Balani*, (few), *Doris pilosa* and *nodosa*, *Gunnellus vulgaris*. Plant—*Fucus serratus*.

In the Mediterranean province, the Littoral zone is exceedingly narrow, a mere strip along the water's edge. Its characteristic testacea are—on rocky ground, *Littorina neritoides*, *Fossarus adansoni*, *Kellia rubra*, *Mytilus minimus*, *Haliotis lamellosa*, *Conus mediterraneus*, *Purpura hæmastoma*, *Fasciolaria tarentina*, *Patella scutellata*, and *Ochthosia*. On sandy ground, *Nassa mutabilis*, and *Neritoides*, and *Mesodesma donacilla*. *Dictyota dichotoma*, *Padina pavonia*, and *Corallina officinalis*, are characteristic plants. In the Indo-Pacific province, *Patella*, *Haliotis*, *Conus*, *Cypræa*, *Oliva*, *Fasciolaria*, *Mitra*, *Nassa*, *Quoya*, *Purpura*, *Littorina*, *Trochus*, *Turbo*, *Nerita*, *Mytilus*, *Corbis*, *Cypricardia*, *Cardium*, *Mesodesma*, *Mactra*, and *Tellina*, are the genera of Testacea which have most characteristic representatives. We do not know much about the distribution of fishes in this zone. Respecting the Indo-Pacific littoral plants, information is sadly defective: it would seem that Florideous Algæ take the place of *Fuci*. In the Australian (South) Province, species of *Parmophorus*, *Haliotis*, *Conus*, *Littorina*, *Turbo*, *Cerithium*, *Planaxis*, *Trochus*, *Nassa*, *Purpura*, *Risella*, *Mytilus* (*erosus*,) *Arca*, *Clavagella australis*, *Cleidotherus*, are the chief littoral forms. The *Terebratula australis* is found on the verge of, or within, this zone, grouped in considerable numbers. Respecting the littoral plants, Dr Hooker informs me that *Moniliformia Billardrei* takes the place of *Fucus vesiculosus* in Tasmania, and probably also in South Australia. In Lord Auckland's group, *Marginaria* and *Xiphophora* replace it. In Kerguelen's Land, and at Cape Horn, (where there is no *Marginaria*,) *D'Urvilæa* takes the place of *Fucus vesiculosus*.

II. CIRCUMLITTORAL ZONE.

Between low-water mark, and about fifteen fathoms, is the principal belt of submarine vegetation, constituting, in the North Atlantic, the *Laminarian Zone*. In the Arctic and Boreal Seas, this belt of tangles is the resort of numerous species of fish and invertebrate animals. Among the former, species of *Merlucius* and *Merlangus* are very characteristic. Among the latter, univalves of the genera *Margarita*, *Lacuna*, *Admete*, and *Buccinum*, bivalves of the genera *Astarte*, *Leda*, *Yoldia*, *Cardium*, *Saxicava*, *Tellina*, and *Cardita* (*arctica*) of Echinoderms, the *Echinus neglectus*, and several kinds of *Ophiura*, prevail. The number of kinds in each genus is but small, as compared with the number of individuals.

In the Celtic Seas this zone is separated from the Littoral region, wherever there is rocky ground, by narrow belts of peculiar sea-weeds, especially *Laurencia pinnatifida*, *Conferva rupestris*, *Chondrus crispus*, and *Himanthalia lorea*. Its main portion is planted on stony or rocky ground with *Laminaria*, on sandy ground with *Zostera*. The olivaceous sea-weeds are mingled with Rhodospermous or purple kinds, species of *Delesseria*, *Rhodomela*, *Hutchinsia*, *Ceramium*, and *Callithamnion*; these red-tinted kinds prevailing in the lower part of the belt, but ceasing to be abundant before the *Nullipora polymorpha*, or coral-weed, which abounds in the deeper section of the circumlittoral zone, prevails. The number of animals, vertebrata and invertebrata, whether we reckon by species or by individuals, is very great. *Blennius*, *Labrus*, *Pollachius*, may be cited among genera of fishes. Of Molluscs, *Nudibranchiata* are plentiful, and species of *Trochus*, *Lacuna*, *Patina*, *Rissoa*, *Pullastra*, and *Ascidians*. Echini and Zoophytes are also very numerous.

In the Mediterranean province, the circumlittoral zone is thronged with beautiful fishes, especially *Sparoideæ* and *Labridæ*. The genus *Iulis*, among the latter, may be taken as a type of the brilliant painting of the characteristic forms of this belt. Cuttle-fishes abound in it. Numerous testacea of the genera *Bulla*, *Rissoa*, *Trochus*, *Dentalium*, *Phasianella*, *Pleurotoma*, *Cerithium*, *Murex*, *Nassa*, *Lucina*, *Tellina*, *Pecten*, *Cardium*, with peculiar characteristic species, such as *Natica olla*, *Turbo rugosus*, *Ranella gigantea*, *Mitra obsoleta*, *Marginella clandestina*, *Solecurtus strigillatus*, *Solenomya mediterranea*, *Cardita calyculata* and *trapezia*, *Spondylus gaderopus*, and *Lima squamosa*, give a distinctive aspect to its molluscan fauna. *Zostera* is the prevailing plant on rocky ground, and instead of Laminaria, *Caulerpa*, with numerous rhodospermous kinds. *Padina pavonia* is abundant on rocks at its uppermost bound.

In the Indo-Pacific province, *Sargassum* probably represents, in some manner, *Laminaria*. Species of *Calyptræa*, *Mitra*, *Ovula*, *Strombus*, *Triton*, *Terebra*, *Turritella*, *Ranella*, and *Cerithium*, *Donax*, *Mactra*, *Corbula*, *Pectunculus*, *Arca*, &c. This is the chief zone of reef-building corals, species of *Madreporidæ* and *Astreidæ*; also of crinoids, star-fishes, and sea-urchins, of which *Clypeaster* and *Scutella* are characteristic Indo-Pacific types. The fishes are often exquisitely brilliant in their painting. *Scarus*, *Balistes*, *Chætodon*, may be cited as characteristic genera.

In the South-eastern Australian province, *Phasianella*, *Elenchus*, *Struthiolaria*, *Myadora*, *Trigonia*, and peculiar species of *Mactra*, *Psammobia*, *Calyptræa*, *Nassa*, *Mitra*, *Marginella*, are examples of the molluscs of this zone. *D'Urvillæa* is the characteristic plant of the upper portion—*Macrocystis* and *Leponia* outside of it, *Nullipora* ranging beyond.—(Hooker.)

III.—MEDIAN ZONE.

From 15 to 50 fathoms may be taken as the average range of depth in this belt. Of its constitution in the Arctic seas we still require details. Star-fishes of the genera *Ophiopeltis* and *Ctenodiscus*, *Holothuriæ*, such as *Cuvieria*, Ascidians of the genus *Boltenia*, and Brachiopodous molluscs, may be cited amongst its most northern inhabitants. In the Celtic seas, it is abundantly peopled, both by fish and invertebrata. Among the former, the cod is one of the characteristic forms, though strictly derived from the Boreal province. Hydroid Zoophytes, as the larger species of *Sertularia*, *Plumularia*, and *Antennularia*, are very abundant; also Bryozoa. *Scallop* banks and beds of *Pectunculus*, amid which live numerous genera and species of testaceous molluscs, abound in many places. This is the region of depth known as the *Coralline zone* in the Celtic seas. Sea-weeds are exceedingly scarce, and only stragglers when present.

In the Mediterranean province, sea-weeds (at least in the Ægean) are common in this province; species of *Dictyomenia*, *Sargassum*, *Codium*, *Cystoseira*, *Chrysimenia*, and *Rytiphlæa*; also nullipores. In its upper part, corallines are frequent and plentiful; also Retepores and other Bryozoa. Sponges also abound, Echinoderms, and tunicated molluscs. Species of *Nucula*, *Cardium*, *Pecten*, *Turritella*, and *Dentalium*, are prolific in it. *Cardita aculeata* is one of its characteristic bivalves.

In the Indo-Pacific, Echinoderms of the genera *Cidaris* and *Astrophyton*, molluscs of the genera *Murex*, *Turritella*, *Dentalium*, *Cardium*, and *Pecten*, appear to prevail.

In the Australian province, hydroid zoophytes, with molluscs of the genera *Dentalium*, *Turritella*, *Cardita*, *Cypricardia*, *Pectunculus*, and *Nucula*, are characteristic forms.

IV.—INFRA-MEDIAN ZONE.

Between 50 and 100 fathoms may be taken as the usual place of this bathymetrical region. In the Arctic and Boreal Seas it is frequented by peculiar fish, such as certain species of *Molva*, *Sebastes*, and *Chimæra*. Annellides of the genus *Ditrupa*, Radiata such as *Comatula*, and sponges such as *Tethya*, frequent it.

In the Celtic seas it is marked by the presence of Brachiopods in greater abundance than higher up; by the genera *Astrophyton* and *Cidaris* among Echinoderms; by the sponge *Tethya*, and the coral *Oculina*. Few shells seem to be peculiar to it; but those found in its lower portions—even if species that are brightly coloured in lesser depths—here become pale or colourless. It is known also as the region of deep-sea corals. No algæ are found in it. Hard and coral-like Bryozoa are common.

In the Mediterranean this is the region of the red or precious coral. It abounds in Brachiopods, especially species of *Terebratula* and *Argiope*. *Cidaris* is its characteristic genus of Echinoderms. Fuci have become exceedingly rare, and at length Nullipores only remain. Testacea, such as *Turbo sanguineus* and *Lima elongata*, are characteristic, with certain species of *Venus*, *Nucula*, *Pecten*, *Emarginula*, and *Pleurotoma*.

We are unacquainted with the features presented by this zone in the southern hemisphere.

V.—ABYSSAL ZONE.

By this name I designate the region of animal life (vegetable, at least conspicuous vegetable, being absent) that extends from about 100 fathoms, or rather under, to the greatest depths in which hitherto living beings have been found. According to my own observations, it would appear to be the lowest of the zones, and to exhibit distinct indications of an approach to a zero of animal life, since the number of species inhabiting it can be shown to diminish as we descend, and not to be replaced by others.

In the Arctic and Boreal Seas, certain fishes, species of *Beryx*, *Gobius*, and *Gadus*, are characteristic of it. Zoophytes of the genera *Alcyonium*, *Primnoa* and *Umbellularia*, Echinoderms of the genera *Cidaris*, *Brissus*, and *Astrophyton*, but with few Testacea, appear to be its distinguishing inhabitants. In the Celtic Seas we can just trace this region, it not having been rightly explored. *Ditrupa* and *Terebratula cranium* appear to be among its most marked types.

In the Mediterranean, where it seems to be floored with a sea-bed of fine mud, peculiar forms of *Arca*, *Nucula*, *Syndosmya*, *Neæra*, *Kellia*, *Limæa*, *Dentalium*, and *Ditrupa*, are characteristic of it. They are all remarkable for the paleness or transparency of their hues. Several remarkable *Ophiuridæ*, and abundance of Foraminifera, aid in giving it a peculiar zoological facies.

Indications of its South African fauna have been made known by Sir Edward Belcher, who procured remarkable species of *Terebratulina*, *Pectunculus*, and *Voluta*, in great depths, off the Cape of Good Hope. Also of its Antarctic fauna, by Sir James Ross. Species of *Primnoa*, remarkably representative of the northern type, of Retepores and other Bryozoa, and of Foraminifera, were dredged by that distinguished navigator at very great depths.

As we descend in the sea, the regions of depth become of greater extent, and the range of species greater. This is well shown by the diagrams of the proportionate vertical dimensions of the bathymetrical zones in the Ægean. In that figure the surface only of I. represents the littoral zone, the sea in question being nearly tideless. The greater part of divisions I., II., and III. represent the Circumlittoral zone; IV. and V. constitute the Median zone; VI. and VII. the Infra-median; and VIII. the Abyssal region.

DIAGRAM ILLUSTRATING THE COLONISATION OF THE BRITISH SEAS.

The area of which the British Islands are the centre, although constituting in itself the main portion of the Celtic province, has been invaded by many races belonging nominally to other regions. These irruptions partly date prior to the present arrangements of land and water. Part of our marine fauna can be traced to the older pliocene epoch—that in which the Coralline Crag originated; another portion dates from the epoch of the Red Crag; a third from the glacial period—all these being anterior to the constitution of the Celtic province, as now displayed. Farther back than the pliocene epoch we can scarcely trace the history, at least within our own area, of the species still existing on it.

In the marine fauna of the British Seas, we may recognise nine elements:

I. *Lusitanian species.* These occur almost exclusively in the English Channel. The *Echinus lividus* of the west coast of Ireland is an exceptional, and perhaps the most ancient, member of this type.

II. *South British* forms, possibly of Lusitanian origin. These occupy considerable districts on our southern and western coasts, and are probably gradually migrating northwards.

III. Species generally diffused, and common to all the European seas, the original centres of which must be determined by tracing out their relative history and points of maximum development in time and space.

IV. The assemblage of characteristic *Celtic* forms, species which are either peculiar to the province, or have conspicuously their maximum development within it.

V. Celtic species that are peculiarly *British*. The number of these is becoming reduced yearly, in consequence of the discovery of supposed peculiarly British species in other parts of the Celtic area, or even in other provinces.

VI. *Atlantic species.* These are those that range from the north of Britain even along the coasts of Spain and Portugal, but which, within the British Islands, are peculiar to the western portion of their seas.

VII. *Oceanic* or *Pelagic* forms, common to the whole or greater part of the Atlantic, and belonging to genera or species that habitually frequent the open sea, and whose distribution is not determined by the neighbourhood of land.

VIII. *Boreal* forms; occupying limited and peculiar tracts within our area, and all belonging to species which we can distinctly prove to be original members of the Boreal, and some few even of the Arctic province. These animals I regard as the descendants of members of the fauna of this area as it existed during the glacial epoch, and to be preserved in localities which have undergone no change from sea into land since that period, or at least within limited areas of which such localities are the centres whence these northern forms have been diffused.

Some of the more striking points in the distribution of these elements are delineated in the diagram map by examples selected from among remarkable species of Mollusca and Radiata, and by washes of colour.

Thus the *green* portion of the sea represents that section of the area in which the foundation-fauna is entirely *Celtic;* whilst in the portion coloured *pink* a large amount of species of southern origin share in the constitution of the general fauna.

The fringing belt of *yellow*, along the west coast of Britain, and all around Ireland, indicates that portion of our shores along which littoral molluscs of the truly *Western* and *Atlantic* type range.

The *blue* patches on coast and in open sea indicate areas where we find assemblages of Boreal or Arctic species congregated in the manner alluded to above.

The curved lines indicate the limits of invading types; those that are *red* being the northern limits of types of *southern* origin; those that are *blue*, the southern limits of species of *northern* origin.

The *red* line dividing the red area from the green, indicates the general limit of southern types—the majority of *South British* forms. The three *red* loops within it represent the limits of *Echinus lividus*, *Cytherea chione*, and *Haliotis tuberculata*—molluscs that may be regarded as members of as many distinct migrations—the first probably being most ancient.

The *blue* loops, on the other hand, represent the extent to which migrations from the north have proceeded—*Acmæa testudinalis* is an example of the most extended, (setting aside those certainly derived from the ancient glacial fauna); *Trichotropis borealis*, indicating a stage less in diffusion; *Fusus norvegicus*, and *Rhynconella psittacea*, a diffusion confined to the deeper parts of the North Sea; and *Echinus neglectus*, the distance to which a probably purely Arctic element has made its way southwards within the British area.

DIAGRAM ILLUSTRATING GENERIC CENTRES.

A large proportion of the well-marked genera of animals and plants occupy more or less limited, but definite, areas on the surface of the earth or in the sea. Such areas have been termed *generic centres.*

When a generic centre of some extension includes a considerable number of species, there is found to be within it a point of maximum, round which the number of species becomes less and less.

A genus may have more centres than one; in every such case the centres or areas are representative.

A genus may have had an unbroken extension at one epoch, and yet, in the course of time and change, may have its centre so broken up that there shall appear to be outlying points not representative.

When the history of a natural genus shall have been traced equally through its extensions in *time* and *space*, it is not improbable that the area, considered in the abstract, will be found to be necessarily unique.

The diagram illustrates, by select examples taken from among marine animals, some of the more striking conditions exhibited by generic centres during the present epoch. These are expressed by circumscribed spaces projected on a plane divided into nine belts or zones, representing the Homoiozoic belts. These areas are wide or narrow, according to the development of species; consequently the wider portion of each represents the point of maximum, so far as the Homoiozoic belt is concerned.

1. *Littorina* (Mollusca gasteropoda) is an instance of a genus, which may be said to have nearly the greatest amount of geographical extension, and to be cosmopolitan. As is often the case in such genera, the development of number of species is very equable, and the point of maximum but slightly indicated.

2. *Patina*, (Mollusca gasteropoda.)—This genus illustrates the development of two centres representative of each other, and dependent on similar and favourable conditions in corresponding regions of the northern and southern hemispheres.

3. *Cypræa*, (Mollusca gasteropoda.)—This genus, consisting of numerous species, most naturally allied, has a well-marked maximum of development in the Central Homoiozoic belt. Southwards its range extends to a less distance than northwards, where we find its outermost species within the North Circumpolar belt.

4. *Voluta*, (Mollusca gasteropoda.)—In this group we have the contrary arrangement, the species ceasing much sooner in the northern than among the southern belts. Thus, taking the genus in its fullest signification, we find the *Voluta* (*Cymba*) *olla* ceasing at Lisbon, and constituting the solitary outguard of the group, whilst *Voluta magellanica* is one out of several that range along the southernmost coasts of South America.

5. *Admete*, (Mollusca gasteropoda.)—A small genus confined entirely to one polar belt, and, so far as known, not represented within the other.

6. *Lacuna*, (Mollusca gasteropoda.)—A genus ranging through three belts, all of the northern hemisphere, and not represented in the southern.

7. *Mitra*, (Mollusca gasteropoda.)—A considerable genus, with a well-marked point of maximum and concentration of its species, but remarkable for having a single outlying species far removed within the North Polar belt. In this case we know, from geological research, that the intermediate space where the group has now no representatives, had formerly *Mitræ* included in its fauna.

8. *Chætodon*, (Fish.)—A case more limited, but corresponding with 3.

9. *Cottoideæ.*—A group of fishes exhibiting a comparable distribution with case 2.

ENUMERATION OF FAMILIES AND GENERA OF ANIMALS AND PLANTS WHOSE NAMES ARE INSCRIBED UPON THE MAP.

Accipenser (Pisc.), a genus of ganoid fishes of the order *Sturiones*.
Acmæa (Moll.), a genus of patelliform gasteropoda.
Acmæa testudinaria, a species characteristic of the littoral zone of the arctic and boreal regions. It ranges southwards to the north-western provinces of the British seas.
Adacna (Moll.), a genus of *Cardium*-like bivalves, really allied to *Pholadomya*, and peculiar to the Aralo-Caspian region.
Admete (Moll.), a genus of prosobranchiate gasteropoda, probably allied to the *Cancellariadæ*.
Agassizia (Echin.), a genus of sea-urchins of the family *Spatangidæ*.
Alcyonium arboreum (Zooph.), a remarkable arborescent asteroid zoophyte inhabiting the depths of the North Atlantic.
Anarrhicas (Pisc.), a genus of osseous fishes of the family *Blenniidæ*.
Aplysia (Moll.), the typical genus of the family *Aplysiadæ*, a group of opisthobranchiate gasteropoda.
Aporrhais pes-carbonis (Moll.), a univalve of the family *Cerithiadæ*, inhabiting the depths of the Celtic seas.
Arbacia (Echin.), a genus of *Cidaritidæ*, all the species of which are tropical.
Arca (Moll.), a genus of dimyarian lamellibranchiate bivalves, the type of the family *Arcadæ*.
Arca imbricata.
Argiope (Moll.), a genus of palliobranchiate bivalves, known also as *Megathyris*. The species, for the most part, inhabit considerable depths.
Ascidia (Moll.), the typical genus among simple tunicata.
Astarte (Moll.), a genus of dimyarian lamellibranchiate bivalves, belonging to the family *Cyprinidæ*.
Astreidæ (Zooph.), a family of helianthoid zoophytes, the genera and species of which are among the principal of reef-building corals.
Astropyga (Echin.), a genus of sea-urchins of the family *Cidaritidæ*; it is allied to *Diadema*.
Astrophyton (Echin.), a genus of starfishes of the order *Ophiuridæ*, and family *Euryales*.

Balistes, *Balistidæ* (Pisc.), plectognathous fishes of the order *Schlerodermi*. They are popularly known as file-fishes.
Bembras (Pisc.), a genus of fishes of the family *Cataphracti*.
Beryx (Pisc.), a genus of fishes of the family *Percidæ*.
Beroidæ (Acal.), a family of ciliograde Medusæ.
Boltenia (Moll.), a genus of pedunculated simple tunicata.
Blennius (Pisc.), osseous fishes of the family *Blenniidæ*.
Blepsias (Pisc.), a genus of fishes of the family *Cataphracti*.
Bouchardia (Moll.), a genus of brachiopoda of the family *Terebratulidæ*.
Bovichthys (Pisc.), a genus of osseous fishes, allied to *Uranoscopus*.
Brachiopoda (Moll.), the order of palliobranchiate bivalves.
Breynia (Echin.), a genus of sea-urchins of the family *Spatangidæ*.
Brissus (Echin.), a genus of sea-urchins of the family *Spatangidæ*.
Brosmius (Pisc.), a genus of osseous fishes belonging to the cod tribe.
Buccinum (Moll.), a genus of siphostomatous gasteropoda of the family *Muricidæ*.
Buccinanops (Moll.), a genus of siphostomatous gasteropoda of the family *Muricidæ*.

Calypeopsis (Moll.), a genus of prosobranchiate gasteropoda of the family *Calyptræidæ*.
Cancellaria (Moll.), a genus of prosobranchiate gasteropoda, the type of the family *Cancellariadæ*.
Capulus (Moll.), a genus of prosobranchiate gasteropoda, of the family *Calyptræidæ*.
Cardita (Moll.), a genus of lamellibranchiate bivalves of the family *Cyprinidæ*.
Cardita arctica.
Cardium (Moll.), a genus of dimyarian lamellibranchiate bivalves, type of the family *Cardiadæ*.
Cassis (Moll.), a genus of siphostomatous gasteropoda.
Caulerpa (Algæ), a genus of sea-weeds.
Cestracion (Pisc.), a genus of sharks (the Port Jackson shark) belonging to the order *Cestraciontes*, most of whose members are extinct.
Chætodontidæ, *Chætodon* (Pisc.), osseous fishes belonging to the order *Percæ*.
Cheletropis (Moll.), a genus of floating univalves, probably allied to *Spirialis*.
Chiton (Moll.), the type of the family *Chitonidæ*, multivalve-shelled gasteropoda.
Chitonellus (Moll.), a genus of the family *Chitonidæ*.
Chimæra (Pisc.), a genus of cartilaginous fishes, the type of the family *Chimæridæ*.
Chimæra monstrosa.
Chimæra antarctica.
Cidaris (Echin.), a genus of sea-urchins, type of the family *Cidaridæ*.
Cleidothærus (Moll.), a genus of lamellibranchiate bivalves of the family *Chamidæ*.
Cleodora (Moll.), a genus of testaceous pteropoda, with triangular shells.
Clio borealis (Moll.), a pteropodous mollusc, without a shell.
Clupea (Pisc.), the genus of osseous fishes to which the herring belongs.
Clupea pilchardus.
Clupea harengus.
Clypeaster (Echin.), the principal genus of the family *Clypeasteridæ*, among the sea-urchins.
Columbella (Moll.), a genus of siphostomatous gasteropoda, allied to *Purpura*.
Comatula (Echin.), a genus of crinoids, free when adult, fixed when young.
Comatula europæa.
Concholepas (Moll.), a genus of siphostomatous gasteropoda, nearly allied to *Purpura*.
Conus (Moll.), the type of the family *Conidæ*, among the prosobranchiate gasteropoda.
Conus mediterraneus.
Corallina officinalis (Algæ), a genus of lithophytes.
Corallines (Zooph. and Moll.), this term is applied to the corneous and flexible forms of hydroid zoophytes and bryozoa.
Corallium rubrum (Zooph.), the red coral of commerce, an asteroid zoophyte.
Corbis (Moll.), a genus of lamellibranchiate bivalves of the family *Lucinidæ*.
Cottoideæ (Pisc.), a tribe of osseous fishes, nearly allied to the gurnets.
Crania (Moll.), a genus of brachiopoda, type of the family *Craniadæ*.
C. norvegica.
C. personata.
Crassatella (Moll.), a genus of lamellibranchiate bivalves.
Crenella (Moll.), a genus of lamellibranchiate bivalves, belonging to the family *Mytilidæ*.
Crepidula (Moll.), a genus of patelliform gasteropoda belonging to the family *Calyptræidæ*.
Criseis (Moll.), a genus of pteropoda with acicular shells.
Ctenichthys (Pisc.), a genus of osseous fishes, allied to *Hemerocætes*.
Ctenodiscus (Echin.), a genus of starfishes of the family *Goniasteriæ*.
Cucullæa (Moll.), a genus or sub-genus of dimyarian lamellibranchiate bivalves, belonging to the family *Arcadæ*.
Cumingia (Moll.), a genus of lamellibranchiate bivalves.
Cumingia californica.
Cyclopterus (Pisc.), a genus of osseous fishes of the family *Cyclopteridæ*.
Cyclopterus liparis.
Cymba (Moll.), a genus of siphostomatous gasteropoda of the family *Volutidæ*.
Cypræadæ, *Cypræa* (Moll.), a family and genus of prosobranchiate gasteropoda, with convolute shells.
Cypricardia (Moll.), a genus of lamellibranchiate bivalves.
Cyprina (Moll.), the type of the family *Cyprinidæ*, among the lamellibranchiate bivalves.
Cytherea (Moll.), a genus of lamellibranchiate bivalves of the family *Veneridæ*.
Cytherea chione.

Dentalium (Moll.), the type of the family *Dentaliadæ*, consisting of tubular-shelled abnormal gasteropoda.
Dentalium sexangulare.
Dictyomenia (Algæ), a genus of sea-weeds.
Ditrupa (Annel.), a capito-branchiate annelide, living in a shell resembling that of *Dentalium*.
Dolium (Moll.), a genus of siphostomatous gasteropoda, allied to *Buccinum*.
Durvillæa (Algæ), a genus of sea-weeds.

Eburna (Moll.), a genus of siphostomatous gasteropoda, allied to *Nassa*.
Echineidæ (Pisc.), a family of fishes of the Blenny group.
Echinometra (Echin.), a genus of sea-urchins of the family *Cidaridæ*.
Echinoneus (Echin.), a genus of sea-urchins, belonging to the family *Galeritidæ*.
Echinus (Echin.), a genus of sea-urchins of the family *Cidaridæ*.
Echinus neglectus.
,, *lividus*.
,, *sphæra*.
,, *monilis*.
Eupatagus (Echin.), a genus of sea-urchins of the family *Spatangidæ*.

Faorina (Echin.), a genus of sea-urchins of the family *Spatangidæ*.
Fossarus (Moll.), a genus of holostomatous gasteropoda, allied to *Littorina*.
Fucus (Algæ), a genus of melanospermous sea-weeds.
Fusus (Moll.), a genus of siphostomatous gasteropoda of the family *Muricidæ*.

Gadus (Pisc.), the typical genus of the cod tribe.
Gadus abyssorum.
Gadidæ (Pisc.), the cod tribe.
Gena (Moll.), a genus of auriform gasteropoda.
Glycimeris siliqua (Moll.), a genus and species of dimyarian lamellibranchiate bivalves.
Gobioideæ (Pisc.), a family of osseous fishes.
Gobius (Pisc.), the typical genus of the preceding family.
Goniaster (Echin.), a genus of starfishes, the type of the family *Goniasteriæ*.
Goniodiscus (Echin.), a genus of starfishes, belonging to the family *Goniasteriæ*.
Gunnellus (Pisc.), a genus of osseous fishes of the Blenny family.

Haliotis (Moll.), a genus of auriform-shelled gasteropoda, the type of the family *Haliotidæ*. The species are all inhabitants of the littoral zone.

Haliotis asinina.
,, *albescens*.
,, *coccinea*.
,, *cracherodi*.
,, *elegans*.
,, *japonica*.
,, *kamptschatica*.
Haliotis midæ.
,, *nævosa*.
,, *rubicunda*.
,, *squamata*.
,, *tuberculata*.
,, *ziczac*.

Harpa (Moll.), a genus of siphostomatous gasteropoda, allied to *Buccinum*.
Harpa rosea.
Harpagifer (Pisc.), a genus of fishes of which there is only one known species, abundant among kelp on the shores of Cape Horn; its position, zoologically, is between *Callionymus* and *Platypterus*.
Heliocidaris (Echin.), a genus of sea-urchins, belonging to the family *Cidaridæ*.
Hemilepidotus (Pisc.), a genus of osseous fishes, allied to the gurnets.
Hinnites giganteus (Moll.), a monomyarian lamellibranchiate bivalve of the family *Ostreadæ*.
Hippopus (Moll.), a dimyarian lamellibranchiate genus of the family *Tridacnidæ*.
Holopus (Echin.), a genus of fixed crinoids. R. xxiii.
Holothuriæ (Echin.), soft echinoderms of the order *Holothuriadæ*.
Hornera (Moll.), a genus of coralloid *Bryozoa*, some of the species of which occur at very great depths.
Hyalæa (Moll.), a genus of testaceous oceanic *Pteropoda*.
Hydroida (Zooph.), an order of zoophytes, including numerous corallines.

Ianthina (Moll.), a genus of pelagic pectenibranchous univalves.
Idmonea (Moll.), a genus of coralloid *Bryozoa*, the species of which inhabit great depths.
Iulis (Pisc.), a genus of osseous fishes of the wrasse tribe.
Kraussia (Moll.), a genus of brachiopodous bivalves, allied to *Terebratula*.

Labrus (Pisc.), the typical genus of the wrasse tribe.
Labroideæ (Pisc.), the family of *Wrasses* among osseous fishes.
Lacuna (Moll.), a genus of holostomatous univalves of the family *Littorinidæ*.
Laganum (Echin.), a genus of sea-urchins of the family *Clypeasteridæ*.
Laminaria (Algæ), a genus of large sea-weeds.
Leda (Moll.), a genus of lamellibranchiate bivalves belonging to the *Arcadæ*, and distinguished from *Nucula* by having prolonged siphons.
Lepadogaster (Pisc.), a genus of osseous fishes of the family *Cyclopteridæ*.
Lepidosiren (Pisc.), anomalous fishes, in many respects approaching reptiles.
Lichina (Algæ).
Limacina arctica (Moll.), a genus and species of spiral-shelled pteropoda.
Liotia (Moll.)
Littorina (Moll.), a genus of pectenibranchiate testaceous gasteropoda, characteristic of the littoral zone.

Littorina aberrans.
,, *africana*.
,, *aspera*.
,, *auraucana*.
,, *canariensis*.
,, *conica*.
,, *grandis*.
,, *helenæ*.
,, *intermedia*.
,, *kurila*.
,, *littorea*.
,, *melanostoma*.
,, *miliaris*.
,, *modesta*.
,, *obtusata*.
,, *pagodus*.
,, *peruviana*.
Littorina picta.
,, *porcata*.
,, *pulchra*.
,, *punctata*.
,, *rugosa*.
,, *scabra*.
,, *sinensis*.
,, *sitchana*.
,, *spinulosa*.
,, *strigata*.
,, *squalida*.
,, *subtenebrosa*.
,, *tigrina*.
,, *tenuis*.
,, *varia*.
,, *ziczac*.

Lobophora (Echin.), a genus of sea-urchins of the family *Clypeasteridæ*.
Lophobranchii (Pisc.), the order of fishes to which the pipe-fishes belong.
Lovenia (Echin.), a genus of sea-urchins of the family *Spatangidæ*.
Lucina (Moll.), a genus of lamellibranchiate bivalves, type of the family *Lucinidæ*.

Macrocystis (Algæ), a genus of large sea-weeds.
Madreporidæ (Zooph.), a family of reef-building corals.
Magilus (Moll.), a genus of pectenibranchiate gasteropoda.
Mangelia (Moll.), a genus of fusiform shells, belonging to the family *Conidæ*, and allied to *Pleurotoma*.
Marginella (Moll.), a genus of convolute univalves, belonging to the family *Cypræadæ*.
Megerlia (Moll.), a genus of terebratuliform *Brachiopoda*.
Mellita (Echin.), a genus of sea-urchins of the family *Clypeasteridæ*.
Melo (Moll.), a genus of siphostomatous gasteropoda of the family *Volutidæ*.
Mænidæ (Pisc.), an order of osseous fishes of the family *Percæ*.
Mænoidæ (Pisc.)
Merlangus (Pisc.), a genus of osseous fishes of the cod tribe.
Merlangus polaris.
,, *virens*.
Merlucius (Pisc.), a genus of osseous fishes of the cod tribe.
Mitra (Moll.), a genus of siphostomatous gasteropoda.
Mitra groenlandica.
Modiola (Moll.), a genus of lamellibranchiate bivalves of the family *Mytilidæ*.
Molva (Pisc.), a genus of fishes of the cod tribe.
Monoceras (Moll.), a genus of siphostomatous univalves, allied to *Purpura*.
Moniliformia (Algæ), a genus of sea-weeds.
Monocentris (Pisc.), a genus of fishes of the family *Cataphracti*.
Morhua (Pisc.), a genus of the cod tribe.
Murex (Moll.), the type of the *Muricidæ*, a family of siphostomatous univalves.
M. brandaris.
Mycedia (Zooph.), a genus of reef-building corals.
Mya (Moll.), type of the family *Myadæ* among dimyarian lamellibranchiate bivalves.
Myochama (Moll.), a genus of lamellibranchiate bivalves.
Myadora (Moll.), a genus of lamellibranchiate bivalves, allied to *Pandora*.
Mullus (Pisc.), the typical genus of the mullet tribe.
Mytilus (Moll.), type of the *Mytilidæ* among lamellibranchiate bivalves.
Mytilus minimus.

Natica (Moll.), type of *Naticidæ*, a family of holostomatous gasteropoda.
N. herculea.
Nassa (Moll.), a genus of *Muricidæ* among siphostomatous univalves.
Neæra (Moll.), a genus of *Corbulidæ* among lamellibranchiate bivalves.
Notothenia (Pisc.), a genus of fishes allied to the *Gobiidæ*.
Nullipora (Algæ), a genus of lithophytes.

Oculina prolifera (Zooph.), a helianthoid coral.
Ophiopeltis (Echin.), a genus of brittle-stars of the family *Ophiuræ*.
Oliva (Moll.), a genus of siphostomatous univalves.
Oreaster (Echin.), a genus of starfishes of the family *Goniasteriæ*.
Oplichthys (Pisc.), a genus of fishes of the family *Cataphracti*.

Paludestrina (Moll.), a genus of holostomatous univalves.
Padina pavonia (Algæ), a sea-weed of the family *Dictyotaciæ*.
Parmophorus (Moll.), a genus of patelliform gasteropoda.
Patina (Moll.), a genus of patelliform univalves, usually considered a section of *Patella*. The species live on kelp.
Patella (Moll.), type of the *Patellidæ* among prosobranchiate gasteropoda.
Patella deaurata.
Pecten (Moll.), a genus of monomyarian bivalves of the family *Ostreadæ*.
Pecten groenlandicus.
,, *hoskynsi*.
Pectunculus (Moll.), a genus of *Arcadæ* among the lamellibranchiate bivalves.
Pentacrinus (Echin.), a genus of crinoids, most of the species of which are extinct.
Phasianella (Moll.), a genus of holostomatous univalves of the family *Trochidæ*.
Pholadomya (Moll.), a genus of lamellibranchiate bivalves of the family *Myadæ*, most of whose species are extinct.
Phorus (Moll.), a genus of holostomatous univalves, type of the family *Phoridæ*.
Placuna (Moll.), a genus of monomyarian lamellibranchiate bivalves.
Placunanomia (Moll.), a genus of monomyarian lamellibranchiate bivalves.
Poromya (Moll.), a genus of dimyarian lamellibranchiate bivalves of the family *Corbulidæ*.
Primnoa (Zooph.), a genus of asteroid zoophytes of the family *Gorgoniadæ*.
Purpura (Moll.), a genus of *Muricidæ* among the siphostomatous univalves.
Purpura hæmastoma.

Quoya (Moll.), a genus of testaceous gasteropoda, allied to *Planaxis*.

Retepora (Moll.), a genus of compound *Bryozoa*, assuming the form of reticulated corals.
Rhynconella (Moll.), a genus of brachiopoda of the family *Terebratulidæ*.
Rhynconella psittacea.
Ricinula (Moll.), a genus of siphostomatous univalves, allied to *Purpura*.
Rissoa (Moll.), a genus of holostomatous univalves of the family *Littorinidæ*.
Rotula (Echin.), a genus of sea-urchins of the family *Clypeasteridæ*.

Salmacis (Echin.), a genus of sea-urchins of the family *Cidaridæ*.
Salmo (Pisc.), the typical genus of the salmon tribe.
Sargassum (Algæ), a genus of melanospermous sea-weeds.
Saxicava (Moll.), a genus of dimyarian lamellibranchiate bivalves of the family *Gastrochænidæ*.
Scarus (Pisc.), a family of osseous fishes belonging to the wrasse tribe.
Sciænoideæ (Pisc.), a family of osseous fishes belonging to the order of *Percæ*.
Scorpæna (Pisc.), a genus of osseous fishes belonging to the gurnet tribe.
Sebastes (Pisc.), a genus of osseous fishes belonging to the gurnet tribe.
Septifer (Moll.), a genus of lamellibranchiate bivalves of the family *Mytilidæ*.
Siphonaria (Moll.), a genus of patelliform univalves.
Siphonaria lessoni.
Solenella (Moll.), a genus of lamellibranchiate bivalves of the family *Arcadæ*.
Solarium (Moll.), a genus of trochiform holostomatous gasteropoda.
Sparoideæ (Pisc.), a family of osseous fishes of the order *Percæ*.
Spatangus (Echin.), the typical genus of sea-urchins of the family *Spatangidæ*.
Spirialis (Moll.), a genus of fusiform-shelled pteropoda.
Strombus (Moll.), the type of the family *Strombidæ* among the siphostomatous univalves.
Struthiolaria (Moll.), a genus of prosobranchiate gasteropoda, allied to *Aporrhais*.
Syndosmya (Moll.), a genus of lamellibranchiate bivalves of the family *Tellinidæ*.
Syndosmya profundissima.

Tellina (Moll.), typical genus of the family *Tellinidæ* among the dimyarian lamellibranchiate bivalves.
Terebra (Moll.), a genus of siphostomatous univalves.
Terebratella (Moll.), a genus of *Brachiopoda*, allied to *Terebratula*.
Terebratula (Moll.), type of the family *Terebratulidæ* among the brachiopodous bivalves.
Terebratula cranium.
Terebratulina (Moll.), a genus of the family *Terebratulidæ* among the brachiopodous bivalves.
Tethya (Zooph.), a genus of sponges.
Tetrodontidæ (Pisc.), a family of plectognathous fishes of the order *Gymnodontes*.
Thecidia (Moll.), a genus of brachiopodous bivalves, type of the family *Thecidiadæ*.
Trichotropis (Moll.), a genus of prosobranchiate univalves belonging to the family *Cancellariadæ*.
Trichotropis borealis.
Tridacna (Moll.), type of the *Tridacnidæ*, a family of lamellibranchiate bivalves.
Trigonia (Moll.), a genus of lamellibranchiate bivalves, type of a family allied to *Arcadæ*, and composed almost entirely of extinct shells.
Triton (Moll.), a genus of *Muricidæ*, among the siphostomatous univalves.
Trochus (Moll.), type of the *Trochidæ*, among the holostomatous univalves.
Trophon (Moll.), a genus of *Muricidæ*, among the siphostomatous univalves.
Trophon clathratum.
Turbinolia (Zooph.), a genus of helianthoid corals.
Turritella (Moll.), type of the family *Turritellidæ*, a family of holostomatous univalves.

Umbellularia (Zooph.), a genus of asteroid zoophytes, allied to *Pennatula*.
Umbrina alburnus (Pisc.), a fish of the family *Sciænidæ*.

Venus (Moll.), type of the family *Veneridæ*, a family of dimyarian lamellibranchiate bivalves.
Virgularia finmarchica (Zooph.), a species of the family *Pennatulidæ*, among the asteroid zoophytes.
Voluta (Moll.), type of the family *Volutidæ*, family of siphostomatous univalves.
Voluta costata.
,, *magellanicus*.
Vulsella (Moll.), a genus of lamellibranchiate bivalves, allied to *Avicula*.

Waltonia (Moll.), a genus of terebratuliform brachiopoda.

Yoldia arctica (Moll.), one of the *Nuculidæ*, among the lamellibranchiate bivalves.

Zostera (Pl. Vasc.), a genus of monocotyledonous plants of the family *Naiadæ*. The species are remarkable for inhabiting salt water.

PLATE 32

ETHNOLOGY,

OR THE

DIFFERENT NATIONS AND TRIBES OF MAN, TRACED ACCORDING TO RACE, LANGUAGE, RELIGION, AND FORM OF GOVERNMENT.

BY

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REVISED AND EXTENDED TO 1854.

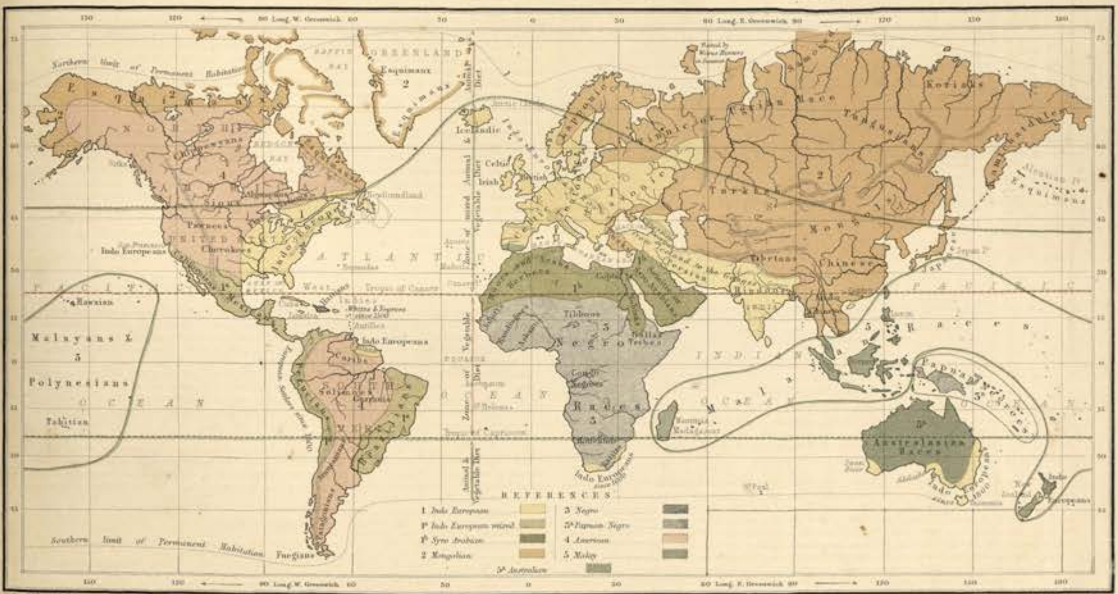
INTRODUCTORY REMARKS.

Ethnology, or the relation of the races or varieties of mankind to each other, must, in the first instance, be based on a knowledge of the existing varieties of the Human Family which we find scattered over every habitable region of the Earth—constituting what may be termed the *Ethnography* of the subject. Unlike the lower animals, whose physical aspects and determinate instincts we have alone to consider, the history of the human species has to deal not only with physical peculiarities, but with mental manifestations, and especially with the great exponent of these—Language. As Man is a migratory being, beyond that of any other animal, the traditions and histories of his migrations are also included as elements in the study of Ethnology. When we consider that the physical aspects of Man are modified to a greater or less extent by climate, localization, mode of life, and intermixtures of races, and that languages are continually changing, both from external circumstances and internal moral and intellectual causes, we need not be surprised at the extreme difficulty and uncertainty which has attended the rise and progress of this particular department of scientific inquiry—more especially as it is a science deriving little assistance from the labours of preceding generations.

From the peculiar structure, in several respects, of his physical frame, as well as his mental endowments, Man is justly placed at the head of organized beings. Like these, he is to a certain extent subject to the influence of external circumstances, but in his constitution he is more cosmopolite: he is found in all localities of the globe, where the extremes of temperature do not absolutely preclude organic existence—under every zone of climate, and at all varieties of altitude, from the sea-shore or the most depressed valley to the very verge of the snow-line of the highest mountains. In this respect, then, his continuous geographical distribution differs from that of all other animals. Physiologists are agreed that there is nothing in the anatomical structure or physical constitution of Man which would prevent the conclusion that all the varieties existing on the globe may have originated from one family and species. On the contrary, there are all the elements which go to establish identity of species—the same anatomical structure—the same period of gestation—a prolific offspring resulting from an intermixture of races—the same instincts, and the same kinds of mental manifestations. On purely scientific grounds, then, the identity of the human race as one species is an inference. The terms *Race, Type, Variety*, may therefore be considered as indicating distinctions, more or less wide, of the human species, or they may stand simply as ethnographic distinctions, without reference to theory at all.

In taking a very general survey of the earth, there are three points, corresponding nearly to the centres of the three great continents of the Old World, around which will be found ranged three remarkable sections of the human family. In Asia, taking the elevated table-land of Tibet as a centre, there is included, under a wide circumference, the **Mongolian**, with broad head, angular face, oblique eyes, tawny skin, rough straight hair, and scanty beard—in Africa the **Negro**, with elongated head, projecting jaws, curly hair, and black skin—in Europe and South-western Asia, the round or oval head, vertical and symmetrical features, fair complexion, and ample beard. These have been distinguished, by the earlier ethnologists, by the terms *Mongolian, Ethiopian*, and *Caucasian*—names which, though not unexceptionable, have been long recognized, are well known, and are sufficient to characterize what may be assumed as the three primary types.[1] Other forms, among which are conspicuous the Malay, the American, the Polynesian, and Papuan, we shall arrange as subordinate; because it seems not improbable that such have arisen out of combinations and modifications of the three primary types. It is remarkable that from the very earliest dawn of all history and tradition, and from the unmistakable indications of very ancient paintings and sculptures, we obtain the knowledge of the existence of distinct and well-marked differences in the aspects of the races of Man; while, since the period of authentic history, we also know that the great centres of the leading types have continued permanent and unchanged, and that, where changes of localities have taken place, the migrating races have retained much of their distinctive peculiarities, notwithstanding the difference of climate and other external circumstances to which they have been subjected.

ETHNOGRAPHIC MAP OF THE PRESENT DISTRIBUTION OF MAN ON THE EARTH.



Preliminary to the ethnographic details which are to follow, it will be necessary to explain certain terms which are used in the descriptions of the various physical forms, as well as in the modifications in the languages of the different races.

The greatest differences of form are found in the bones of the head and face.

The general form of the cranium gives rise to three divisions—

I. Where the skull is elongated from the forehead to the occiput, and narrow between the two parietal bones, and where the arch of the cheek-bone (*zygoma*) is also elongated,—in other words, where the occipito-frontal diameter greatly exceeds that of the parietal, the skull is called *sterno-bregmate*, or *dolikho-kephalic*, as in the Negro races.

II. Where the skull is more nearly round, where the parietal diameter nearly equals the occipito-frontal, and where the zygomatic arches are also large and projecting,—forming the *platy-bregmate* or *brakhy-kephalic* skull of the Mongol.

III. Where the skull is nearly oval, and the zygomatic arch of moderate size, forming the *meso-bregmate* skull of the Caucasian.

When the frontal bone is nearly vertical, or gently arched, the forehead is capacious; but when it greatly recedes backwards, and is of small proportions, the forehead is low, the face, and especially the mouth, projecting forwards. The Greek head and face afford an example of the former, and that of the Negro the latter. By drawing a line from the external orifice of the ear to the base of the nose, and another line from the sloping forehead to the projecting teeth, we obtain, in the inner angle, the *facial angle* of Camper, which is largest in the Greek head and smallest in the Negro. When the teeth are inserted perpendicular to the base of the nose, the skull is said to be *orthognathic;* when the teeth project forwards, as in the Negro, *prognathic*.

Language being in man the expression of his emotions and passions, as well as of his intellectual powers and acquirements, must have varied greatly according to the various circumstances and conditions through which he has in the course of successive ages passed. At first simple, common to all; then broken up as families and tribes separate, wander far apart, acquire new habits, become acquainted with new objects, follow different pursuits, or more or less exercise their mental activities, give wing to their imagination, and expand their knowledge into particulars, or, cultivating their intellects, learn to separate, compare, and generalize. We accordingly find that language has come down to us in various stages and under various forms, with certain great leading characteristics pervading the whole, and even with numerous roots which are more or less common to all the known tongues spoken on the earth,—these resemblances appearing even as frequently among the most remote tribes and nations, who have been separated as much by space as by time, as among those who are known to have lived very near to each other for thousands of years.

We find languages changing not only in words, or *glossarily*, but also grammatically; some that have scarcely moved beyond their primitive stage, some are half-way onwards in their development, others retrograde, many made up of the ruins of older tongues, and not a few highly-polished ones nearly sunk again into primitive barbarism. It will be enough here to specify three modes of language—

I. A language of single words or syllables, without inflexions, without affix or prefix, or articles or adjuncts of any kind. Such is the *monosyllabic* or *aptotic* language of the Chinese.

II. Languages where the primitive words are changed or modified by additional syllables put to the end so as to express time, gender, number, &c., called inflexional—as the Greek, Latin, Sanscrit; or where the inflexions are internal, as in the trisyllabic form of the Semitic or Hebrew languages.

III. Languages both with inflexions and affixes and suffixes, as the English. The English may be said also generally to have dropped inflexions, which the original Saxon possessed, and to have adopted affixes and suffixes instead.

In inflexional language there are two classes recognised: in one, with inflexions composed of words that were formerly separate; in the other, with inflexions where this separation cannot be traced.

Of the groups of races and nations which have languages nearly allied may be specified:—

The Monosyllabic group.—The Tibetans, Chinese, Nepaulese, Burmese, Siamese, and in some degree the Japanese.

Malay and Polynesian group.—Inhabitants of the Asiatic archipelago and South Sea islands; languages similar, with the exception of the Papuan Negroes, whose language is different.

American group.—Languages of North and South America agree in grammatical structure, with great glossarial varieties.

Tartar or Taurian group.—The language essentially the same over the whole area.

Semitic group.—Modern languages based on the ancient Hebrew, including Syrian, Arabic, ancient Coptic.

African group.—Allied to the Semitic. The Negro and Kaffir languages, in second stage of progress, all grammatically and glossarially allied.

Indo-European group.—Modern languages based on the Sanscrit, including Persian, Hindoo, Afghan, Teutonic, Slavonic, Celtic, Iberian.

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[1] Blumenbach, the father of Physical Ethnology, first imposed these terms. Cuvier adopted them into his *System of Nature*, and ever since they have been generally recognised, notwithstanding that almost every writer on the subject comes prepared with a new nomenclature. If we simply receive these terms in a general sense—*Mongolian* as expressive of a vast region in Central Asia, *Ethiopian* in its ancient acceptation of "*dark-skinned*," and *Caucasian* as indicating a range of mountains which lie midway between Europe on the west and south-western Asia on the east, we shall thus obtain sufficiently expressive denominations for the great leading divisions of the human family; observing also a rule which, if possible, should be complied with in natural science, of preserving as nearly as may be the names imposed by the original pioneers of each particular department. The other divisional terms, *American* and *Malay*, have met with fewer rivals, and are sufficiently expressive. In subdivisions, a greater latitude of invention may be permitted, especially in a new and rapidly-extending department of science.

MONGOLIAN TYPE.

The skull is of a square shape, rather angular than rounded—platybregmate; head of a heavy form, though not large; capacity varying from 69 to 73 cubic inches; facial angle sloping backwards from 70° to 80°. The cheek-bones are high, and project outwards; the nose is flat, and on the same level with the cheek-bones; the arch of the eyebrow is scarcely perceptible; nostrils narrow; the edge of the jaw slightly rounded forwards and the chin prominent. The face is broad and flattened, without any distinguishing depression; the space between the eyes is flat and very broad; lips generally well-formed, and not thick: cheeks round and projecting; nose broad and flat. The line of the outer eyelids extends towards the temples, the skin being drawn up by the unusual protuberance of the cheek-bones, while the internal angle is depressed towards the nose, and the upper eyelid at this point is continued into the under lid by a rounded sweep, the eyes thus appearing as if placed obliquely; eyes small, and iris dark. Skin of an olivaceous tint, varying from sallow lemon-peel to brownish yellow, but never very fair or intensely swarthy. Hair coarse, lank, and black; beard scanty, not curly, partially or wholly wanting at the ears, and hair scanty on other parts of the skin. Body square, stature rather low, trunk long, extremities rather short, wrists and ankles weak. Animal energy less than that of the Caucasian; less enduring of toil or bodily exertion; fond of horseback, or sedentary labour; sluggish, dirty. Intellect only moderately developed; but shrewd, sagacious, crafty, insincere; more obstinate than brave; savagely cruel to vanquished foes, and when subdued readily reduced to order; evading rather than resisting oppression by force; jealous and fearful of foreign intrusion; imagination and taste deficient; mind conversant with the material rather than the ideal; imitative and skilful in domestic arts, but without any scientific enterprise; content with a stationary civilization, whether that of nomadic herdsmen and shepherds, or dwellers in cities. Religious aspirations obtuse; Shamanism or demon-worship, a materialistic morality, Polytheism, Buddhism, and Mohammedanism forming the native and adopted creeds. Language mostly monosyllabic, without inflexions; inartificial, and limited in range of literature: Turkish, Japanese, and some other languages inflexional. Occupies the whole of central, northern, and eastern Asia, from the Arctic Ocean to the equator, and from the Ural Mountains and borders of the Black Sea to the shores of the Pacific, including the most elevated regions of the globe, and extremes of temperature from the greatest cold to the warmth and moisture of the tropics. There are numerous varieties and intermixtures on the Asiatic continent; a few in Europe. To these may with probability be added extensive aboriginal tribes inhabiting the Deccan and other central portions of Hindostan; and the Malay, Polynesian, and American races partake largely of the Mongolian peculiarities.

The Mongolians generally are an inland or continental people, nomadic shepherds and herdsmen, or fishers in the arctic seas. On the eastern and southern shores a proportion become navigators engaged in commerce. From the earliest stages of society they seem to have roamed widely over the globe, both on the west into Europe, and on the east through the Asiatic archipelago, and probably across the Pacific to America. The ancient hordes of fierce warriors who poured from the north under the names of Scythians, Kimmerii, Alans, Avars, Huns, were probably wholly or partly of this great division of mankind. From the eleventh to the thirteenth century the Turks poured westward, till they occupied Asia Minor, Syria, the south-eastern parts of Europe, and the north of Africa. By this progress, and intermixtures with the nations which they conquered, the physical character of the Mongol has gradually approached and merged into that of the Caucasian, as exhibited in the Turk of Constantinople.

Races.	Area of Occupation.	Language.	Religion.
	CENTRAL ASIA.		
Tibetans,	Tibet, Ladakh, Butan, Little Tibet.	Monosyllabic.	Buddh., Brahm., Moham.
Chinese,	South-eastern Asia, basins of Hoang-Ho, and Yang-tse-Kiang.	Monosyllabic.	Buddh., Confucius.
Burmese,	Valley of Irawaddy. (Partake of Malay character).	Monosyllabic.	Buddh.
Anamese,	Tonkin, Cochin-China.	Monosyllabic.	Buddh.
Siamese,	Siam, part of Assam.	Monosyllabic.	Buddh.
Kambojians,	Lower valley of Mekong river.	Monosyllabic.	Buddh.
Mon, &c.,	Delta of Irawaddy, Pegu.	Monosyllabic.	Buddh.
	NORTHERN ASIA.		
Samoeids,	North division—Shores of Arctic Ocean, from river Petchora to river Yenisei. South division—Altai Mountains, near sources of Obi and Yenesei rivers.	Partly monosyllabic.	Shamanism.
Ostiaks,	Valley of Obi, east of Yenisei. (A nation of fishers).	Partly monosyllabic.	Shaman., Christian.
Yeniseians,	Upper basin of Yenisei river.	Partly monosyllabic.	Shamanism.
Tungus, Yakutsk,	North-eastern Asia, from the Yenisei to Sea of Okhotsk.	Partly monosyllabic.	Buddh., Paganism.
	TAURANIAN.		
Finns,	Various tribes on the Volga. Finns of Sweden and Norway.	Various dialects.	Christian.
Lapps,	North part of Scandinavian peninsula.		Imperfect Christian.
Magyars,	Hungary, mixed with Europeans. (Original Ugrian migration, A.D. 900).		Christian.
Koreans,	Peninsula of Korea.	Not monosyllabic.	Religion of Fo, modified.
Japanese,	Japanese Islands, Loo-Choo Islands, lower basin of Amoor, Saghalin Island.	Inflexional, alphabet Chinese.	Buddh., Confucius, Pagan.
Kamtchatdales, Koriaks,	Peninsula of Kamtchatka.	Not monosyllabic.	Shamanism.
Esquimaux,	Along the whole arctic coasts of Asia and America. Language of the coast of Greenland intelligible to the natives of Labrador.	Inflexional, various.	Pagan, Christian.
Mongolians,	The eastern half of high or middle Asia; and basin of the Volga, by migration.	Inflexional.	Buddh.
Turks,	The western half of middle Asia, from Lake Baikal to the Black Sea in Europe. Physical character passing from Mongolian into that of the other nations with whom they are intermixed.	Inflexional, uniform over whole area.	Mohammed., Buddh., Christ. in Siberia.

MALAY SUBDIVISION.

The **Malays**, scattered over the islands of the Indian and Pacific Oceans, exhibit considerable diversities of form and of civilized progress. The Malay range extends from Madagascar in the west to Easter Island in the South Pacific, half-way between Asia and America; and from Formosa on the north to New Zealand on the south. Within this extensive range there are two marked divisions of the inhabitants—the **Malay**, properly so called, and the **Papuan** or **Negrito**.

Asiatic Malay.—The normal character of the Malay is as follows:—Head rather small, measuring in capacity, according to Dr Morton, 64 to 89 cubic inches; platybregmate; the dome of the skull is high and rounded, with a low forehead; the face broad, flat, and rounded; cheek-bones high, cheeks rather hollow; nose short, small, expanded at the wings, but not flat; mouth wide; upper jaws projecting, and angle of lower jaw very prominent; teeth prognathic—the auditory aperture is elevated, the orbital ridges prominent and overhanging. Skin various shades, from clear brown to dark olive and bright yellow; hair of head black, straight, shining, and generally rough, scanty on the body and chin, the few hairs of the beard being pulled out as they appear at puberty. Persons short, squat, and generally robust, though sometimes lank and spare; lower limbs rather large and heavy, but well shaped; arms rather fleshy than muscular. Medium height of men, 5 feet 2 inches; of women, 4 feet 11 inches; great bodily activity, and considerable manual ingenuity.

The **Malay** has no central focus where the normal type is concentrated, or from whence it may have diverged, for the Malayan peninsula has all the characteristics of an island. The nearest approach to the Malay form on the central continent is that of the Burmese; but they are more Hindoo in aspect and language than the generality of Malays.

The physical form of the Malay is Mongolian, modified probably by an admixture of the Hindoo, Arabian, and African. His moral temperament also varies. The true Malay is treacherous, ferocious, implacable, with a diminished sensibility to bodily pain. When stimulated to frenzy by narcotics, he rushes forth like an infuriated animal, and recklessly attacks all he meets: this is called *running-a-muck*. Excessive gambling and the use of narcotic substances, such as the betel-nut, opium, tobacco, are the vices of the more civilized portion; cannibalism, head-hunting, or preserving the heads of enemies, and piracy, are the vices of the more savage; tatooing the body, filing the teeth, and other mutilating customs, are also common. All have maritime tastes, and commercial and emigrating voyages are prevalent. The prou, an ingeniously-constructed boat, is the native vessel. A milder and more intellectual temperament prevails in some of the Polynesian varieties. The ancient civilization of the Malay was derived from Arabia, Hindostan, and China; the later European settlers have also had some influence.

The language, which is founded on the Sanscrit, is fundamentally the same throughout all the Malay region (with the exception of the Papuan Islands); but the dialects vary greatly in number, and to such an extent as not to be mutually understood. The alphabets and written literature are borrowed from the Arabic and Sanscrit.

The dominant religion is Mohammedanism; Christianity to some extent has been introduced, and Paganism is widely prevalent. The localities are:—

Malayan peninsula.
Sumatra.
Java.
Borneo.
Timor.
Celebes.
Philippine Isles.
Moluccas.
Formosa.

The **Polynesians** have the Malayan physical characters somewhat modified. The stature of some of the island groups is taller, with a tendency to corpulence, such as the Sandwich and Society Isles. The features are more like the American red men—the nose frequently aquiline, the skin lighter coloured, the hair soft, wavy, and curled; but there are also intermixtures of dark-skinned and crisp-haired, as the Feejee islanders, intermediate between the Polynesian Malay and the Papuan Negrito. The native food is chiefly amylaceous and saccharine roots and fruits, with an absence of the cultivated cerealia, and very little animal food. Languages allied to each other and to the Malay. Religion—Paganism, with introduced Christianity and civilization from Europe. Supposed stream of migration from east to west, and the proximate centre of diffusion over Polynesia was probably the Samoan or Navigator's Isles. Principal island groups—Navigator's, Society, Friendly, Sandwich, and New Zealand.

Papuan.—From Sumatra to the Feejee Islands, and including the Philippines, there is found a race differing in physical characters and in language from the normal Malay. In the islands of the western part of the archipelago they form only part of the population, and they occupy generally the centre or more inaccessible parts of the islands: apparently a conquered and depressed race. In the eastern portion of the archipelago, from New Guinea to New Hebrides, they form the sole population of the islands. Their physical aspects, like that of the true Malay, vary considerably; but, on the whole, they resemble the Negro and Kaffir of Africa more than the Mongolian type. In the western islands this is more apparent than in the eastern—the crisp curly hair, projecting mouth, flat nose, wide nostrils, large oval eyes, thick lips, and harsh black skin being prevalent; frequently a diminutive stunted race, with lower extremities slender, high calves of the legs, and projecting heels.

The Papuan of New Guinea and Torres Strait is described as of taller stature, with round outline of body, and muscular limbs; features frequently regular; nose projecting and sometimes aquiline, but broad at the base; forehead broad, but not high; cheek-bones prominent; lips rather thick; skin deep reddish-brown; the hair of the head growing out from the scalp in separate tufts or pencils, having a woolly mop-like curl, but not crisp like the Negro. This is exactly the character of the Bosjesman of South Africa, and agrees with portraits of the Ababde Arab. The intellect is low, and the construction of the warlike arms, canoes, and huts, is far inferior to that of the Malay. The Papuan language, in so far as known, is essentially different from that of the Malay, but contains Malay words. The principal Papuan islands are New Guinea, and smaller isles immediately surrounding it—New Ireland, Salomon Isles, the Louisiade Archipelago, New Hebrides, New Caledonia, Tasmania, and Australia.

The **Australian** forms a subvariety. The head is large, with very projecting eyebrows; deep-set eyes; nose broad; mouth wide; skin varies from dark chocolate-brown to deep black; hair dark and matted, but when clean, smooth and straight. The figure is spare, and there is a marked lankness of the extremities. The perceptive faculties are acute, but the reflective deficient. There is no approach to civilization—no arts, no industry; nor do they ever appear to have had any in the past periods of their history. There appears to be no distinctions of rank, and no attempts at general government beyond that of paternal rule. One radical language pervades the whole country; but the dialects are so various that even neighbouring tribes scarcely understand each other.

The geographical boundary of the Papuan islander is precisely coincident with that of the north-west monsoon. This wind, from the months of November to March inclusive, is the prevalent one over all the space extending from the equator to 10° or 15° south latitude, and in longitude from Sumatra to the Feejee Islands. It is sometimes experienced to the west of Sumatra as far as the north of Madagascar, and it sometimes also extends to the east of the Feejee Islands into the Pacific Ocean; but these extensions are irregular, and its usual eastern boundary is precisely that of the Papuan race. Hence the presumption is that this people, little skilled in the art of navigation, have come from the west into the Pacific, and extended their migration only as far as the monsoon favoured them.[1] A second migration of the more civilized and more ingenious Malay extended over a wider range.

Madagascar.—This is, perhaps, the place to notice the island of Madagascar. Its present population is more African than Malay, but the language is more Malay than African. The Hovas of the interior preserve traditions of the existence of a small-sized tribe of Negroes called *Vazimbers*.

AMERICAN SUBDIVISION.

The aborigines of North and South America, though exhibiting considerable diversity of form, have a general physical aspect which is common to the whole. The general form of the skull approaches the Mongolian in shape, but the summit is more rounded, and the sides are less angular. In some, the back part of the crown is elevated and pointed, and the occiput flattened. Artificial flattening of the forehead is also practised by some tribes. The very small flattened skull of the ancient Peruvian is also characteristic of a race now probably extinct. The cheek-bones are high; the forehead rather low and retreating; the nose prominent, not unfrequently aquiline; jaws powerful; teeth perpendicular; mouth large; lips full; eyes small, deep-set, and black; hair coarse, black, and rather scanty; beard long of appearing, and scanty. Skin of a red copper-colour, and glossy in some North American tribes; and of a yellowish red, olive, light brown, and sallow hue in the various tribes of South America. On the north-west coast the Esquimaux characteristics prevail; and among some tribes grey eyes and comparatively fair complexions are occasionally seen. The frame is in general symmetrical, rather tumid. Stature varies from middle size to that of six feet and upwards. Habits active, vigilant, daring; revengeful and cruel to enemies, yet susceptible of lofty feelings, hospitable and generous. The intellect of the North American is acute and observant: they entertain an exalted idea of one Great Spirit, yet their religious belief is mingled with debasing Feticism. Language inflexional, with a complicated grammar, and split into innumerable dialects, which differ widely in their glossaries, so as to render the speech of one tribe unintelligible to another. "In America," says Humboldt, "from the country of the Esquimaux to the banks of the Orinoco, and again from these torrid banks to the frozen climate of the Strait of Magellan, mother tongues, entirely different with regard to their roots, have, if we may use the expression, the same physiognomy. Striking analogies of grammatical construction are acknowledged not only in the more perfect languages—as that of the Incas, the Aymera, the Guarani, the Mexican, and the Cora—but also in languages extremely rude. Idioms, the roots of which do not resemble each other more than the roots of the Slavonian and Biscayan, have those resemblances of internal mechanism which are found in the Sanscrit, the Persian, the Greek, and the German languages. Almost everywhere in the New World we recognise a multiplicity of forms and tenses in the verbs,—an industrious artifice to indicate beforehand, either by inflexion of the personal pronouns which form the termination of the verb, or by an intercalated suffix, the nature and the relation of its object and its subject, and to distinguish whether the object be animate or inanimate, of the masculine or feminine gender, simple or complex in number."

The Mexicans and Peruvians, at the time of the Spanish conquest, had attained a considerable degree of civilization, and possessed large cities and temples. Agriculture and the arts were practised, and roads afforded intercommunication with different parts of the empires. Their astronomical knowledge appeared to intimate some early connection with India. They had no written literature, but an approach to hieroglyphic writing. Indications of a communication with the north-eastern parts of the Asiatic continent and the north-west of America are also traceable. The civilization of North America appeared in a much less forward state than that of the centre. Rude mounds of a sepulchral and religious character exist on the west of the Rocky Mountains, and are very numerous in the great valley of the Mississippi, containing in the interior rude pottery, shells, and other relics; and remains of houses or temples, built of large stones, exist in New Mexico; and a few families, as the Pimos, have villages and a little agriculture; but there is nothing else among the tribes generally which would indicate a state of civilization beyond that of the hunter life.

The pastoral state appears to have been totally unknown in America; and this is to be accounted for from the total absence of all domestic quadrupeds. Agriculture was practised to some extent among the more civilized tribes. War and hunting were, however, the universal occupations. Scalping of enemies, compression of the skull, and other mutilations of the body, a belief in sorcery, or the influence of *medicine men*, constitute some of their most prominent habits and peculiarities. Sun-worship, Polytheism, and Feticism were their religious creeds. A patriarchal government among the savage tribes, and despotism among the more refined, were the modes of government. The North American nations have never submitted to the influence of the civilization of Europeans, with the exception of the Cherokees and Choctaws; and most of the other tribes are rapidly becoming extinct. The Mexicans, Peruvians, Brazilians, and some other of the South American tribes, have partly amalgamated with the Spanish and Portuguese settlers, forming a mixed race.

The Esquimaux has more decided Mongolian features than the American, yet there are tribes which appear, in physical aspect, to pass from one to the other, and the grammatical structure of the Esquimaux language coincides with that of the American red man. The near propinquity of the Asiatic to the American continent at Behring Strait, suggests the probability of an emigration in this quarter, at the same time that an emigration from Asia, in a more central position, is not unlikely to have been the great focus of transit to the central regions of America.

Aleutians,	Aleutian Isles. Esquimaux.
Koluch,	Cook Inlet to Queen Charlotte Sound. Esquimaux.
Nutkans,	Quadra. Vancouver Island.
Athabaskans,	From Hudson Bay to near Pacific and north-east of Rocky Mountains, comprising Chippewyans, Beaver, Hare, Dog-ribs, Carrier Indians, &c.
Chenooks,	Basin of Columbia river. Short, squat; oblique eyes; fair skin; artificially flattened heads.
Algonkins,	From Rocky Mountains to Newfoundland, and from Labrador on north to South Carolina. Comprise Blackfoots, Shiennes, Bethucks, Leni Lenap, &c.
Iroquois,	Northern: Lakes Huron, Ontario, Erie.—Southern: North Carolina.
Sioux,	Valley of Missouri. Comprise Winnebagoes, Dakotas, Assiniboins, Mandans, Osage, &c.
Cherokees,	Valley of the Tennessee river. Partly civilised, and the only tribe which is not decreasing.
Choctaws,	Lower valley of Mississippi and Florida. Artificially flattened heads. Partially civilized.
Natchez,	Banks of Mississippi, but nearly extinct. Retain the Mexican customs and affinities.
Pawnees,	Valley of river Platte.
Paduces,	Pacific to Gulf of Mexico.
Californians,	Along coast of Pacific to New Mexico.
Aztecs,	Table-land of Mexico. Ruins of ancient cities, and other marks of former civilization.
Maya,	Yukatan. Central America.
Mosquito,	Honduras. Central America.
Quichua, Aymara, Atacamas,	From the equator to 28° south latitude. Colour deep olive; massive form; trunk long in proportion to the limbs.
Chilenos,	From latitude 25° to 40° south.
Patagonians, Fuegians,	From latitude 40° south to Cape Horn. Stature large. Lowest state of barbarism.
Chiquitos, Chaco, Yurucares,	Upper valley of the Pilcomayo.
Moxos,	Valley of the Madeira river.
Guarani,	Brazil, and over the eastern side of South America. Various sub-tribes. Colour yellowish reddish; massive form, moderate height, eyes oblique, delicate features, and physiognomy mild.
Caribs,	From mouth of Amazon and northwards. Lesser Antilles.

ETHIOPIAN TYPE.

The Ethiopian embraces the African central type and its varieties. An elongated narrow cranium, crisp and curly hair, jaws more or less projecting, thick lips, and black or dusky skin, are its general characteristics; but there are two marked divisions—the true **Negro** of Western Africa, and the **Kaffirs** of the South, besides various intermixtures.

In the **Negro** the skull is sternobregmate—narrow and compressed at the sides, and elongated from front to back; the dome arched and dense; the forehead convex, retreating, and narrow; the contour of the head is smooth compared to the angular form of the Mongol; the cheek-bones project forward; the bridge of the nose is small and flat, the nostrils round and wide; both jaws are much elongated, edges narrow and elliptical; front teeth of the upper jaw turned obliquely forward; lower jaw strong and large, and front teeth somewhat oblique. The whole skull is thick and heavy, facial angle from 65° to 70°; the mouth wide, with very thick lips; the face is narrow, and projects greatly in the lower part; chin retracted; eyes prominent and rather large, iris black, vessels of the eye suffused with a bilious tinge. The hair in infants rises from the skin in small mamillary tufts, disposed in irregular quincunx; in adults, it is of a crisp woolly texture, except the eyebrows and eyelashes; beard scanty on the upper lip, and chiefly confined to the point of the chin, except in late manhood; a few tufts of hair are on the breast, but the arms and legs are bare. Hair on the head woolly and curled in the pure races, never hanging loose or rising into a mop; body strong, muscular, and very symmetrical; bones of the fore-arm somewhat elongated; shin-bones of legs slightly bent forward, and calves placed high up; the feet broad, heavy, and soles flat; the heel-bone projecting. Skin soft and silky to the touch: in the new-born infant, dull cherry red—in adults, varying from a deep sallow to an intense black; emits a strong offensive odour, especially under exposure to the sun. The Negro is very patient of hard and protracted labour under a broiling sun, and even in damp and marshy localities, where other races would sink under disease. The Negro willingly shares the labour of the female sex; and for all domestic and agricultural employments they are particularly fitted. The voice of the male is feeble and hoarse, that of the female high and shrill. They are fond of simple and rude melody; are patient, submissive, affectionate, honest, and cheerful, and contented in their dispositions. With an intellect sufficiently acute and perceptive, yet without great depth or comprehensiveness, they, as a race, have never arrived at high civilization, nor excelled in arts, navigation, or commerce. Their language is slightly inflexional, a stage removed from the simplest monosyllabic; without a written literature. Their religion is Feticism or demon-worship, and Mohammedanism among the northern tribes; but in a civilized state they are, as Christians, susceptible of deep devotional feelings. Circumcision and tatooing are both practised. Central Africa, from west to east, is the nucleus of the race, from the southern edge of the Great Sahara lat. 18° north, to the equator; but they thrive in the tropical and sub-tropical parts of America, though a certain elevation of temperature seems necessary for their healthy existence. Without consolidated nations or governments, with no large regular-built cities or extensive commerce, or objects of architectural or other arts, what the Negro is at the present day he seems to have been in the ages that have passed, for no monuments or traditions tell of a different state. Slavery is common; a rude agriculture and inland traffic are generally prevalent, but there is no maritime navigation. Governments, that of petty chiefs or kings: despotic.

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[1] Mr Blaxland; Juke's *Voyage of the Fly*; Macgillivray's *Louisiade Archipelago*.

Tribes.	Area of Occupation.	Religions.
Mandingoes,	Country surrounding Cape Verd on east,	Feticism and Mohammed.
Joloffs, Sereres,	Lower basin of Senegal river,	Feticism.
Foulahs,	Left bank of Senegal river,	Mohammed. and Feticism.
Felups,	Low country; mouth of Casamance river,	Feticism.
Yarriba, Tapua,	Right and left banks of the Niger,	Feticism.
Ashantis, Fantis,	Gold coast; Gulf of Guinea,	Feticism.
Widah,	Dahomey kingdom,	Feticism.
Benins,	Sea-coast; Bight of Benin,	Feticism.
Gribo,	Grain coast,	Feticism.
Ibo,	Lower Niger,	Feticism.
Bornowy,	On Lake Tchad,	Feticism.
Begharim,	River Shary, south of Lake Tchad,	Mohammedanism.
Mouba,	East of Lake Tchad,	Mohammedanism.
Furians, Koldagi,	Kordofan country,	Mohammedanism.
Shilluks, &c.,	Negroes of the White Nile,	Unknown.
Tibboos,	Extend over the eastern Sahara,	Unknown.
Liberians,	A colony and republic of manumitted Africans, restored to their original country from the United States of America,	Christianity.

The region of the Kaffirs, generally speaking, commences at the equator or some degrees north of it, and extends throughout South Africa; but this is not strictly true, for the Loango tribes on the south-west of Africa, and those of the Mozambique borders on the east, form a transition from the normal Negro to the Kaffir, and on the whole are more Negro than Kaffir in physical appearance, and perhaps also in language. The modified Negro character, therefore, prevails on the west coast to about Cape Negro, or beyond it to the tropic of Capricorn, including the—

Batanges, Baawes, Poongas, Loangos, Congos, Benguelas,	Modified Negroes, spread over the coasts and interior of Lower Guinea.

On the east coast to the river Zambese, including the tribes of the Mozambique and Zanguebar coasts and interior there are—

KAFFIRS.

The cranium of the Kaffir rises higher and is more rounded than that of the Negro, and is less platybregmate; the cheek-bones and zygomatic process are projecting, the eyes small and dark, eyelids occasionally oblique; the face tapers to the chin, and the jaws are much less prominent than those of the Negro. The nose is also less depressed; the lips are thick, and mouth large; skin varies from dark brown to copper colour, and clear yellowish-brown. The hair of the head is crisp and curly, and grows in separate tufts; body athletic and well formed; habits pastoral and nomadic more than agricultural; circumcision and tatooing practised; language allied to Negro, but with peculiarity of a prefix to the nouns which has no separate meaning, and an alliteration of the initial letters of words following each other.

Amakosas,	Vicinity of the Cape.
Bechuanas,	North of head-waters of Orange river.
Zoolahs, &c.,	North of Bechuanas.
Damaras,	Still farther north; partly Kaffir, partly Hottentot.

HOTTENTOTS.

Stature low, limbs slightly made, colour brownish-yellow; head round, but flatter than Kaffir; cheek-bones prominent, nose flat and broad at the base, eyelids oblique; hair black, grows out from the scalp in tufts, which curl separately—in mixed races mopped; buttocks often steatomatous, nymphæ enlarged; pastoral and hunters. The *Saab* or *Bosjesmen* very diminutive, fierce, and untamable; language different from Hottentot, and accompanied by a peculiar *click*; inhabit the Karroes or elevated terraces of Southern Africa; roaming hunters; uncivilised; physical structure partly Mongolic; mopped hair resembles that of the Papuas of Australasia.

The Griquas or Bastaards are a mixed race of Dutch and Hottentots. The elements of admixture of races are here amply furnished, partly by slave traffic and partly by foreign emigration, and consist of the Arab, Malay, Malagassi, Dutch, English, Negro.

The Negroes of the United States of America, of the West India Islands, Honduras, Brazil, have been transported chiefly from the Mandingo and other nations of Western Africa, and from Congo and other localities of Lower Guinea.

The mixture of Negro blood with Caucasian forms the following denominations—

Mulatto,	Intermixture of Negro and white.
Sambo,	Intermixture of the Negro and mulatto.
Quadroon,	Mulatto and white.
Mestis,	Quadroon and white.

TRIBES OF NORTHERN AFRICA.

Berbers,	North-west Africa. Negro-Arabic. Language allied to Semitic. Descended from the ancient Gætulians, Numidians, Mauritanians, and Cyrenæans.
Copts,	Delta of Nile, from Essouan to Mediterranean.—Modern Copts, with modified Negro features. Coptic language allied to Semitic with Syrian alphabet. Religion, Christian.—Ancient Egyptians, with physical features intermediate between Negro and Semitic. Skin brownish, with tinges of yellow and red.
Nubians,	Valley of the Nile, Nubia, and Dongola. Semi-Negro type. Skin jet black; hair long and slightly crisp. Religion, Mohammedan and Pagan.
Bishari,	Table-land between the Nile and Red Sea. Similar in appearance and habits to Nubians.
Gallas, Agows,	From Abyssinia to the equator. North-east Africa. More Semitic than Negro in physical aspect and languages.
Abyssinians,	Table-land of Abyssinia. These, with the Arabs of North Africa, ranged under the Semitic subdivisions of Caucasian type.

CAUCASIAN TYPE.

The head is almost round, or somewhat oblong (mesobregmate), and the skull is smooth, rounded, and of the most symmetrical form, with a full development of the anterior portion; the cheek-bones are rather narrow, without any undue projection; the jaws are rounded, the front teeth of each being placed perpendicularly; the capacity of the skull, according to the measurement of Dr Morton, from 75 to 100 cubic inches, the facial angle rising from 75° to nearly 90°. The face is of a round or more generally oval shape, and the features moderately prominent; the forehead arched; the nose narrow, slightly arched, or at least with the bridge somewhat convex; the mouth small, with the lips slightly turned out, especially the lower one, and the outline gracefully waved; the chin full and round; colour of skin fair and ruddy (*Xanthous*), or of various shades of brown (*Melanous*); hair abundant on head and chin—generally soft, smooth, and wavy, and dispersed also on other parts of skin—colour various, according to complexion, from a yellow-red auburn and deep brown to glossy black; colour of iris of eyes also various, from shades of blue to hazel, dark brown, and black; eyes generally full; medium stature, approaching to six feet in the Xanthous, and from five feet three to five inches in the Melanous; muscular strength, energy, and endurance generally considerable—in many superior. Though the physical senses and instincts of the Caucasian are less prominently exercised, in consequence of civilization, yet they appear in the wild Arab and mountaineer of the Hindoo-Koosh as intense as in the other savage tribes. Intellect highly developed, as also æsthetic, poetical, and musical talent; languages polysyllabic, with numerous inflexions and affixes, copious, and intricately and systematically refined. Various subdivisions.

Semitic or Syro-Arabian.—Represented by the modern Syrians, Hebrews (now dispersed), Arabs of Arabia and North Africa, Abyssinians or Ethiopians, and other tribes passing into the Negro; including also the ancient Assyrians and Babylonians, Israelites, Moabites, Ammonites, Edomites, Ishmaelites, Phœnicians. Languages formed on the model of the Hebrew. Ancient religion pre-eminently Monotheistic.

Physical character of the Arab:—Face oval, forehead large and vaulted, nose straight or aquiline, lips thin and well formed; hair wavy or curled; skin dark brown or yellowish; body and limbs spare but active; acute, intellectual, imitative, haughty, and impassioned. Religion originally Sabæan, now Mohammedan.

Georgian, Circassian, Armenian, &c.—Tribes inhabiting the Caucasus and countries between the Caspian and Black Sea. Partly ancient and partly intermixtures of Turks. Physical appearance of the unmixed and probably aboriginal races eminently Caucasian; language doubtful—partly Sanscritic, but more Mongolic than anything else.

Iranian.—This title is here intended to comprehend the countries from the Euphrates on the west to the Indus on the east; and as the Brahminical Hindoos are apparently a people who have in former times entered the peninsula from the west, they may also be classed in the same division. The included tribes, then, consist of Persians, Kurds, Beloochistans, Afghanistans, Kafiristans, and Hindoos. The physical aspects vary from the fair-skinned, aquiline-nosed Persian, the reddish-haired Kurd, the Afghan with much of the Jewish physiognomy, the Hindoo with the Persian features passing into that of the Mongol, and, as in the central tribes of the Deccan, &c., partaking both of the Mongol and Negro. With the exception of these latter tribes, the languages of the others are all based on the Sanscrit.

Hindoos.—The Hindoo skull is rather small and elongated; forehead round, well formed, narrow, but not sloping; features regular; face oval; nose prominent, sometimes aquiline; skin various shades of brown—in the higher castes, and in females, nearly fair; hair black, smooth, and waving; general expression mild, and rather melancholy. Hindoos of the upper provinces tall and robust; in the valleys, height moderate; muscular powers rather feeble; divided into four castes; abstain from eating horned cattle; food chiefly rice. Religion chiefly Brahminism; Buddhism and Mohammedanism partial; ancient language of the Vedas, Sanscrit—modern languages derived from the Sanscrit. Possessed the country north of 22° north latitude for many centuries before the Christian era. Supposed to have first entered the peninsula of India south of latitude 22° about the fifth century of Christian era.

Aboriginal Hindoo Tribes.—Colour darker than the Brahmins, and passing to deep black; nose flattened, cheek-bones prominent, lips thick; hair coarse, generally straight; beard scanty, limbs slender, stature short; language essentially different from the Sanscrit, but many Sanscrit words introduced among the more civilized tribes; religion Paganism; sacrifice of human victims; domestic habits resemble the Tartars; polyandria common. They form the chief population in the southern part of the peninsula from Cape Comorin to the Kistna river and northward; are conterminous with the Hindoo population chiefly in the central mountainous districts, and are distinguished under various names, as Bhils, Gonds, Mahrattas, Beders, Gowlies, Pariahs, Rajmahali; the Brahmi of Beloochistan, &c.

Gypsies.—Originally supposed from banks of the Indus, from whence they have wandered over Europe.

Celtic.—With somewhat elongated sternobregmate skull and melanic complexion; language of the Sanscritic family, but differs in grammatical construction and glossary from Teutonic; apparently separated from the parent stock at a very early period. Allied to Iberians—Cimbri? Entered Europe by the northern shores of the Mediterranean. Ancient distribution, Asia Minor, Tyrol, Illyria, Spain, Gaul, Belgium, North Italy, Britain, Ireland. Original government, feudal vassalage. Ancient religion, pagan, with a system of Druids and Bards.

Grecian.—Pelasgi, Hellenes.

Italian.—Samnites, Etruscans, Celts, Ligurians.

Teutonic, Gothic, or German.—The normal character of the Teutonic tribes is characterised by round broad cranium; blue eyes; yellowish, flaxen, or reddish hair; fair smooth skin and ruddy complexion; large body and limbs, inclined to obesity. The variations are grey hazel eyes; hair, various shades of brown, passing to dark-brown; complexion sallow, swarthy; size various. Teutonic languages have all a close resemblance to each other, and a common affinity to the Sanscrit. Older languages possessed a complicated scheme of inflexions like Greek and Latin, which have now been mostly converted into separate auxiliary words. Ancient localities, western Germany, between the Rhine and the Elbe, and southern parts of Scandinavia; the Mœso-Goths on the Upper Danube, in Roman province of Mœsia, from thence migrating eastward to the Euxine Sea. Two divisions: Ostrogoths, or *East Goths*; Visigoths, or *West Goths*. Present Teutonic localities—Scandinavia; Germany, lower, middle, and upper; Switzerland, Holland, Belgium, Great Britain and Ireland, North America, Australia.

Ancient Teutonic Divisions.			Modern Inhabitants.
1. Herminones,	Suevi, Chatti, Cherusci, Hermunduri,	Central Germany, or High Germans,	Hessians, Thuringians, Franks (intermediate).
2. Ingævones,	Frisii, Chauci, Angli, Batavi,	West and North-west Germany, Low Germans,	Batavians, Saxons, Frisians.
3. Istævones,	Goths, Burgundians, Varini,	North Germany. Mouth of Vistula,	Prussians.
4. Hillevionen,	Cimbri (?)	Scandinavian peninsula,	Danes, Norwegians, Swedes.

Slavonic or Sarmatian.—Skull platybregmate, more square than oval; complexion sallow; hair dark and coarse; eyes dark-brown, deep set; cheek-bones prominent; body stout and broad; great muscular energy. Varieties approaching the Mongol type.

Lithuanian language has the closest resemblance to the Sanscrit of all the Indo-European tongues.

Division 1.	Lithuanians,	North-western. Poland; part of Prussia, Bohemia, Moravia, &c.
" 2.	Russians,	South-eastern. Russia, Wallachia, &c.
" 3.	Lettons,	Intermediate. Lettons, Curons, &c.

ETHNOGRAPHIC MAP OF EUROPE.

In this map three great varieties of the Caucasian division are pointed out—the Celtic by *blue*, the Teutonic by *yellow*, and the Slavonian by *red*. The subvarieties have different shades of these fundamental colours. Wherever there has been a crossing of these varieties, or subvarieties, it is indicated by a *mixed tint*, in such a manner that the colour predominant in the mixture points out the predominant national element. Thus green, in its different shades, points out a mixture of Celtic and Teutonic blood; flesh colour, and other tints mixed of red and yellow, &c., point out a mixture of Teutonic and Slavonian blood. The same principle applies also to the varieties of the Mongolian species which inhabit Europe.

The names of the different varieties and subvarieties have been pointed out by adjectives (many of which are abbreviated on the map), as it appeared more convenient to distinguish the respective populations by names indicative of their origin, which could not have been done if the substantives representing their names of the present day had been used; thus, *e.g.*, the name of Pomeranians, Prussians, &c., does not convey any distinct allusion to their origin, but the compound adjective coupled with the mixture of colour, shows at once what they are. In some instances names have been used which do not indicate, it is true, a peculiar subvariety or particular mixture; but in such cases the difficulty of pointing out the different constituent elements of such a population was too great to be overcome on a general map. Such instances are *Lotharingians, Rheinländers*, &c.

RACES INHABITING EUROPE, IN THE ORDER OF HISTORICAL SUCCESSION.

I. Cyclopean variety. *Physiological character unknown.* Inhabited formerly the islands and shores of the Mediterranean. Of its existence there are, besides fabulous accounts, no other proofs than the gigantic structures to be met with in parts of Greece, Italy, the islands of Malta and Gozzo, &c., which are known under the name of Cyclopean walls, towers, treasure-houses. From ancient skulls, differing somewhat in form and size from those of Europeans, and associated with rude stone warlike implements, found in Scandinavia, Scotland, &c., the existence of an aboriginal Mongolic race in these countries has been surmised.

II. Celtic variety. *Physiological character:* Dark (sallow) complexion; dark-brown eyes and black hair, with a disposition to turn grey at an early age, and to fall out (bald head), commonly not curled; middle size, slender make; legs curved somewhat inwards, as in females; narrow chest, narrow hips; face and upper part of the skull the exact form of an oval; heels and ankles slender, feet small. Temperament: bilious and bilious-nervous prevailing.

Intellectual and Moral character.—Quickness of perception, great powers of combination and application, disposition for concentrating power; love of equality, of society, of amusement, of glory; want of caution and providence; prevalent disposition for sexual intercourse, gallantry, want of respect for human life; want of penetration, of desire for personal independence and political and civil liberty; national pride. Disposition to superstition and hierarchy. Foundling hospitals. In most Celtic countries no law regarding paternity, or for the sustenance of so-called natural children by the father. Fine blandishing manners, great external politeness, without inward sympathy. Irascible, not forgetful of injuries, little disposition for hard work. Bad seamen, and not fit for colonizing.

The Celtic variety comprises the following subvarieties:—

1. *Iberian* subvariety, constituting, so far as we know, the primitive population of Spain and Portugal, and the Balearic Islands, which afterwards became blended with Carthaginians, Romans, Goths, Vandals, Moors. There is only a remnant of it to be found unmixed in the Basque provinces of Spain,[1] and in the south-western parts of France, on the Spanish frontiers. Although this subvariety, according to all probability, preceded the other Celtic subvarieties in Europe, yet there is no sufficient reason to consider it as a distinct variety of the Caucasian species, as is often done; on the contrary, its physiological character renders it necessary that it should be subsumed under the Celtic variety.

2. *Italic-Tuscan-Oscian-Sicilian* subvariety, formed by the ancient inhabitants, so far as we know, of Italy, and Sicily, Sardinia, Corsica, and the neighbouring islands on the western coast of Italy. It afterwards blended with Pelasgo-Grecian and Grecian immigrants, who filled the south of Italy, and part of Sicily. This subvariety attained the highest development in the *Roman typus*, which, after having

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[1] Recent travellers have frequently made mention of the inhabitants of some of the valleys in the Basque provinces, in a manner that should make one suppose them to be remnants of the *Vandals* and *Goths* who went to Spain. For the present, however, on account of an accurate description of their physiological characteristics being still wanting, this point must be left undecided.

crossed Spain, Portugal, France, and parts of Britain, was crossed in its turn by the Vandals, Goths, Longobards, Northmen, and Arabs.

3. *Pelasgo-Grecian* subvariety, inhabiting, in ancient times, the Peloponnesus, Hellas, and the islands of the Archipelago, and of the Ionian Sea. It was at an early period crossed by Teutonic tribes; (the Greeks themselves were nothing but a mixed race of the ancient Celtic inhabitants and Teutonic invaders: the Teutonic character in this mixture being more prevalent in the *Doric* tribe, the Celtic more in the *Ionian*).[1]

4. *Gallic* subvariety, inhabiting, in ancient times, France (Gaul) and Upper Italy, the western cantons of Switzerland (in which French is now spoken), Grisons, and the southern part of Belgium. They were crossed in course of time by the Romans, and the following Teutonic tribes,—the Goths, Burgundians, Franks, and Alemanns.

5. *British* and *Irish* subvariety, the former again subdivided into the *Welsh* and *Cornish*, the latter into the *Irish* proper, the *Manx*, and the *Gaelic*; inhabiting Great Britain and Ireland; in course of time extensively crossed, and partly exterminated by the Teutonic tribes of the Scandinavian peninsula, Denmark, Germany, and Normandy.

6. *Arabian-Hebrew-Celtic* subvariety (known under the name of the Jewish) spread over all countries of Europe, more especially Germany, Poland, and Russia.

III. Teutonic variety. *Physiological character.*—Fair complexion; fair, often flaxen, reddish, golden-coloured smooth hair, commonly not curled; large blue eyes, ruddy cheeks, broad high brow; skull larger and rounder than in the Celtic variety; bones thicker, chest broader, hips thicker, legs straight; heels and ankles strong; feet often large, even clumsy, when compared with the Celtic variety; greater strength of muscle; tallness of figure, above what is called the middle size; skull and face of a form that approaches nearer to a half circle, to which the thinner end of the oval is added; disposition to become corpulent. Temperament: sanguine and phlegmatic prevailing.

Intellectual and Moral character.—Slowness, but accuracy of perception; general slowness, but depth and penetration of mind; not brilliant for witticism like the Celtic variety, but distinguished by acuteness; want of concentrativeness. Fondness of independence, it being valued more highly than equality of condition or rank. Self-government in all spheres of life. Provident, cautious, reserved; hospitable, but not sociable on a large scale, with aristocratic-conservative tendencies, and fond of titles and social distinctions. Respect for women, without assuming the Celtic character of frivolous flippancy. No foundling hospitals. Spirit for benevolent foundations. Recklessness regarding other nations' rights; overbearing, haughty spirit; sincerity; forgetfulness of received injuries. Musical talent in most Teutonic tribes great. Skilful seamen, adventurous, distinguished for cleanliness; on the whole, fond of spirituous liquors. (For explanation of the latter peculiarity, see Liebig's *Animal Chemistry*).

It comprises the following subvarieties:—

1. The *Scandinavian*, inhabiting Iceland, the Faröer, Shetland, and Orkney Islands; Norway, Sweden, Denmark, and the islands on the Danish, Swedish, and Norwegian coasts.

2. The *German* subvariety, inhabiting Germany, Holland, the German cantons of Switzerland, part of Schleswig and Transylvania, and forming the populations of the towns in Curonia, Livonia, Esthonia; in which countries also the gentry in the country are of German origin. No Teutonic tribe has ever been crossed by subsequent conquerors: Teutonic tribes mixed, however, in some localities with the vanquished enemies; but this has taken place in the course of centuries only, as, for instance, in Northern Germany. There is a mixed *Scandinavian* population, however, with prevalent Teutonic character, in Scotland, parts of England and Ireland; and a mixed *German* in England (Anglo-Saxons), with prevalent Teutonic character, the Celtic element in the mixture being comparatively small; and in parts of Mecklenburg, Pomerania, Brandenburg, Silesia, Prussia Proper, Saxony, Bohemia, Styria, Carinthia, Carniola, with tribes of Slavonian origin; and in Suabia, the Black Forest, Alsace, and in the cantons of Basle, Zurich, Argovia, Thurgovia, and St Gall, the German element is probably mixed with the Celtic and Slavonian.

IV. Slavonic variety. *Physiological character.*—Complexion sallow, between that of the Teutonic and the Celtic races; eyes grey, or hazel-brown, and often deep in the head; hair dark in its different shades, not smooth, frequently of a bristly character, rarely curled; form of skull and face more square than oval; cheek-bones frequently prominent; brow low, the hair growing far down upon it. Stature stout and broad, neck short and thick, bones strong, limbs straight; ankle, heel, and foot strong; great muscular strength; hardy in constitution. Temperament: phlegmatic, sanguine-bilious prevailing.

Intellectual and Moral character.—Great mechanical talent, talent for imitation, for music; when subjected, cunning, deceitful, and revengeful; when free, frank, open. Although originally democratic, in consequence of national misfortunes, a great leaning towards a paternal and despotic authority. Blind obedience, tenacious of old manners and prejudices. Love of country, without a spirit of adventure; clever and cunning merchants; want of cleanliness; love of lyrical poetry, more especially elegiac poetry and songs.

It comprises the following subvarieties:—

1. The *North-western Slavonians*, consisting of the Poles, Wenden, Sorbens, Czechs, occupying Poland, parts of Prussia Proper, the eastern borders of Pomerania, parts of Lusatia, the eastern borders of Silesia, Bohemia, and Moravia.

2. The *South-eastern Slavonians*, represented by the Russians (Great and Little Russia), Wallachians, Servians, Slavonians proper, Dalmatians, Croatians, Illyrians, Montenegrins, and Arnautes (Greece), inhabiting the countries which bear their respective names.

3. The *Lettons*, intermediate between the Slavonian and Finnian, but now more especially in Lithuania, much mixed with Slavonians, on the banks of the rivers Niemen and Düna, subdivided into—1. *Lithuanians*, in the governments of Wilna, Grodno, Minsk, Volhynia; 2. *Lettons*, in Livonia, in the country; 3. *Curons*, in Curonia and Semgallia, in the country.

V. The Turks are a mixed race of original Tartar (Mongolian) and Caucasian elements, so that they might be ranked among either; the Caucasian character seems, however, to be prevalent among them at present. In consequence of the very many concurrent elements of this subvariety, it is difficult to assign correct physical types to it, which would be applicable to all of them. To a great extent they still partake physically of the character of the Tartar variety of the Mongolian species (see below), being, however, finer made, their limbs in better proportion, the eyes without the oblique Mongol cut, and invariably with fine noses.

Their intellectual and moral character is as difficult to define: they are haughty, cunning, clever, lazy, ferocious.

They inhabit part of the Turkish empire in Europe (Thracia, Thessaly, Macedonia).

VI. The Finnian variety of the *Mongolian* division comprises the following subvarieties:—

1. The *Finnians* proper, consisting of the Lappons, Quänians, Finnians, Esthonians, in the respective countries which bear their name; Permians (government of Perm); Woguls, on both sides of the river Ural, in the government of Perm; Tscheremesses, on the left bank of the middle part of the river Volga; Tschuwasches, on the banks of the middle division of the river Volga; Mordwines, on the banks of the Oka and Volga, in the government of Nijni and Kazan.

Physiological character.—Skull and face somewhat square, face flat, cheeks receding, dark-grey eyes, sallow-yellowish complexion, brownish hair, beard thin, stature middle size, muscular strength middling, great durability of body. Temperament: phlegmatic-bilious prevailing.

Intellectual and Moral character.—Grave, energetic, hardy, bold, pertinacious, hospitable, but in an extraordinary degree obstinate.

2. The *Samoeidian* subvariety, in the north-eastern part of European Russia, on the shores of the White Sea. *Physiological character.*—General character the same as the preceding, with the peculiarity of broad and flat noses; eyes small, dark-brown or black, lying deep in the head, and in the oblique direction peculiar to the Mongolian species.

3. The *Magyar* subvariety. *Physiological character.*—Complexion sallow; skin often delicate, so that the sallowness is different from that of the Celtic variety; face short; cheek-bones frequently prominent; skull more round than square; eyes small, dark-brown or black, frequently deep in the head, with Mongolian obliquity; hair black, smooth; neck short; stature middle-sized: neither so broad nor so stout as the Teutonic and Slavonic, but equally robust. There is a great difference between the appearance of the higher class (or nobles) and that of the people generally; the former combining, with some of the peculiarities mentioned, as regards the eye and complexion, the fine shape of the face and skull of the varieties of the Caucasian species. The origin of the Magyars is to some extent still doubtful; but according to the best authorities they are originally from north-eastern Asia. In their language, too, there is an affinity with the Finnians. They inhabit the greater part of Hungary.

Intellectual and Moral character.—The higher class is on a par with the most talented in Europe; of a quick mind, bold, valiant, generous, hospitable, haughty, aristocratic. The mass of the people are remarkable for their love of horsemanship, of women, for their hospitality and national pride; but they are deficient in enterprise.

VII. The Tartar variety of the Mongolian division. *Physiological character.*—Body tall, and of what is commonly called middle size; face oval; nose rather broad and flat; mouth small; skin not so sallow or yellowish as with most Mongolian varieties; small bright black eyes, with oblique cut; hair dark-brown and dark, often of a shining, and sometimes of a smooth appearance.

Intellectual and Moral character.—Courage, love of freedom, hospitality, grave manners, peacefulness, laziness.

Inhabits the southern parts of Russia (the northern coast of the Black Sea), the peninsula of Crimea, and the former kingdom of Astrakhan (Volga).

Subvarieties.—1. *Nogaic Tartars*, north from the Caucasus, on the banks of the Kuban and Don, on the shores of the Black Sea, and that of the Sea of Azov.

2. The *Crimean or Taurian Tartars*, in the governments of Taurida, Kherson, and Iekaterinoslav.
3. The *Casan Tartars*.
4. The *Meschtscherjärken*, in the governments of Kasan and Orenburg.
5. The *Baschkir Tartars*, in the governments of Orenburg and Perm.
6. The *Kumuck Tartars*, on the banks of the river Sundscha, one of the tributaries of the Terek.
7. The *Kirghis Tartars*, between the Volga and Ural rivers, and on the coast of the Caspian Sea.

VIII. The Kalmyk (Khalimik) variety of the Mongolian division. *Physiological character.*—Complexion brownish-yellowish-sallow; hair black and rather bristled; head square; cheeks prominent; eyes receding, small; colour of the eyes black, brownish, and greyish, cast oblique; nose broad and flat; stature middle; frame more slender than stout; great muscular power.

Intellectual and Moral character.—Cunning, disposition for depredations, nomadic habits; fond of an intoxicating liquor called *kumiss*, made of fermented steed-milk.

1. Soonjar Kalmyks, 2. Torgot Kalmyks, 3. Derbet Kalmyks,	Between the lower part of the Don and Volga rivers, from Zarizyns to the Caucasus and the Caspian Sea.

To make these notes as complete as possible, mention may also be made here of the Gypsies, Zigeuner (German), Gitano (Spanish), Bohémien (French), Tartars (by Danes and Swedes), who, according to their physical character, belong to the Caucasian species, and probably have come from the banks of the Indus, where there is still a tribe said to exist (Pottinger), called Tchinganee, who, in appearance and language, are like the Gypsies to be found in Europe. The Gypsies made their appearance in Europe about the fourteenth century. Their number is calculated from 400,000 to 600,000 individuals, spread over all countries of Europe. They are very numerous in Spain, the Austrian dominions, and part of Turkey.

Physiological character.—Slender and nimble in limbs, complexion yellow-brownish, black eyes, white teeth, limbs in good proportion. Temperament: bilious-nervous.

Intellectual and Moral character.—The former little developed, not without natural talents, which they exhibit as soothsayers, cobblers, &c. They have a disposition for a vagrant mode of life. Different attempts to settle them in a fixed locality made by several governments (Prussia) have failed. No disposition for agriculture and trade. Their notions of private property little developed; in disposition cheerful and frivolous.

DISTRIBUTION OF THE DIFFERENT VARIETIES OVER EUROPE, ACCORDING TO NUMBERS.

GENERAL FACTS RELATIVE TO THE PURE AND MIXED STATE OF THE DIFFERENT VARIETIES.

I. Races of Men, as well as of other animals, improve by crossing; although, with regard to the former, in consequence of the want of direct experiments, we cannot state what cross-breeds would constitute the finest race. Yet sufficient indications of the correctness of this view are to be found in the fact, that in those countries in which there is a mixed population, not only are the finest specimens of human animals, but also greater energy and versatility of mind to be found—*e. g.*, Ancient Greece, Italy in the middle ages, France, Belgium, and Great Britain. On the other hand, it is a well-known fact, that continual intermarrying between certain families at last deteriorates the race.

II. Nations, in course of time, lose in vitality and productivity, so far as the continuation of the species is concerned. This is evidently the case with the *Celtic* subvariety, which, if we can believe the ancient authors, was formerly far more numerous than at present; whilst, according to a general supposition, they should have increased at a similar ratio with the Teutonic race, for instance, which, on the whole, has been subject, for the last 2000 years, very much to the same external influences. Yet, at the present day, the Teutonic race (including the United States of North America, and the British colonies) outnumbers considerably the Celtic, although its number were, about 2000 years ago, far inferior to the other.

I. *Pure blood.*	
a. *Teutonic*, in the countries above mentioned, about	52,000,000
b. *Slavonian*, in the countries above mentioned, about	50,000,000
c. *Celtic*, in parts of Ireland, Scotland, England, France, Grisons and the western (French-speaking) cantons of Switzerland, about	12,000,000
d. *Jews*,	2,000,000
e. *Finnian and Samoeidian*, in the countries above mentioned, about	3,000,000
f. *Magyar*, in the country above mentioned, about	9,000,000
g. *Tartar*, in the south and south-eastern provinces of Russia,	2,000,000
Total of *pure blood*, about	130,000,000
II. *Mixed blood.*	
a. *Teutonic-Celtic*, the Teutonic prevailing, in Great Britain and part of Ireland, about	22,000,000
b. *Teutonic-Slavonian*, the Teutonic prevailing, in parts of Pomerania, Mecklenburg, Prussia Proper, Silesia, Bohemia, Illyria, Carinthia, Salzburg, Carniola, about	6,000,000
c. *Teutonic*, pure and mixed with Walloons, in Belgium, about	1,200,000
d. *Teutonic-Northmen* in Normandy, and Teutonic-Alemannic and Franconian, in Lorraine, and Burgundian in Franche-Comté, about	1,500,000
e. *Celtic*, in its different varieties and crossed, as mentioned above, in France, Spain, Portugal, Italy, and Switzerland, about	56,000,000
f. *Slavonian*, prevailing in Germany, Bohemia, Wallachia, about	6,000,000
g. *Lettons*,	2,000,000
h. *Turks*,	4,000,000
i. *Turko-Tartar-Slavonian*, from the centre of European Russia, south-east and eastwards,	2,600,000
j. *Kalmyk*, between the Volga and Ural,	300,000
Total of *mixed blood*, about	101,600,000
III. *Summary.*	
Total of *Teutonic blood*, pure and mixed, about	82,700,000
... *Celtic blood*,	68,000,000
... *Jews*,	2,000,000
... *Slavonian blood*,	58,000,000
... *Letton*,	2,000,000
... *Finnian and Samoeidian*,	3,000,000
... *Turks*,	4,000,000
... *Magyar*,	9,000,000
... *Tartar*,	4,600,000
... *Kalmyk*,	300,000
Total of the population of Europe, including 600,000 Gypsies,	231,600,000

The population of Europe (1854) now exceeds this by about twenty-three millions, but the relative proportions remain much the same as here given.

Note.—Mention should be made of the circumstance, that the Teutonic population out of Europe (United States of North America, and the British colonies) amounts to about 30,000,000, so that the total of Teutonic blood would be rather more than 100,000,000.

DISTRIBUTION AND CLASSIFICATION OF THE DIFFERENT VARIETIES OF THE CAUCASIAN AND MONGOLIAN DIVISIONS,

IN THEIR PURE AND MIXED STATE, ACCORDING TO THE LOCALITIES WHICH THEY INHABIT.

I. *Teutonic.* a, Pure.	Scandinavian.	Northman.	Iceland, Farier, Shetland, Orkney Islands, Norway.
		Gotho-	Sweden and the adjacent islands.
		Danish-Jütian.	Denmark and the adjacent islands.
a, Pure.	German.	Saxon.	Hanover, Brunswick, Westphalia, parts of Saxony, Holstein, Mecklenburg, Pomerania, Anhalt, Transylvania.
		Batavian.	North Holland.
		Frisian.	Coasts of the North Sea, both sides of the Elbe and Weser, Holland, Swiss cantons of Schwyz, Uri, Unterwalden (?), upper part of Valais.
		Thuringian.	Parts of Saxony, Saxon Duchies, Principalities of Anhalt.
		Hessian.	Hessia, Middle Rhine, Thuringia.
		Franconian.	Northern part of Bavaria, Middle Rhine, Hessen Darmstadt, Rhenish Bavaria.
		Alemannic.	Part of Bavaria (western), Würtemberg, Grand Duchy of Baden, Alsace, northern cantons of Switzerland, Black Forest.
		Suabian.	Western part of Bavaria, Würtemberg, Black Forest.
b, Mixed.	Scandinavian.	Northman-Scottish.	North and eastern coast of Scotland.
		Northman-English.	Northumberland and Durham.
		Northman-Irish.	North coast, and part of the south of Ireland.
		Danish-Scottish.	Part of the eastern coast of Scotland.
		Danish-English.	Durham, Northumberland, Essex, Sussex.
		Danish-Irish.	Southern and western shores of Ireland.
		Norman-English.	Majority of English counties.
		Norman-Irish.	East of Ireland.
		Northman-French.	Normandy.
		Northman-Neapolitan and Sicilian.	Coasts of Naples and Sicily.
b, Mixed.	German.	Saxon-British-Celtic.	Lowlands and south of Scotland, north-west of England, Cumberland.
		English-Irish.	Eastern coast of Ireland.
		Flamand-German.	Flemish part of Belgium.
		Alemannic-Celtic. Suabian-Celtic.	Würtemberg, Grand Duchy of Baden, Alsace.
		Alemannic-Celtic-Slavonian.	Northern cantons of Switzerland.
		Marcomannian-Celtic-Slavonian.	South and east of Bavaria, Austria.
		Franconian-Lotharingian.	Lorraine.
		Longobardian-Celtic.	Lombardy.
		Gothic-Celtic. Vandalian-Celtic.	Catalonia. Castile. Arragonia.
		Burgundian-Gallic-Celtic.	Burgundy (Franche Comté).
		Saxon-Slavonian. Thuringian-Slavonian.	Pomerania. Mecklenburg. Brandenburg. Silesia, Prussia Proper.
		Franconian-Slavonian.	Fulda and Fichtelgebirge.
	Teutonic-Pelasgo-Celtic.		Ancient Greece.

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[1] What has been said about the ancient crossing of the Pelasgo-Celtic race by a Teutonic tribe (Heraclidean immigration) may appear rather strange and bold. Yet I am not the first to entertain an opinion of the kind, as Dr M'Culloch (*Highlands and Western Islands of Scotland, &c.*, vol. iv. p. 265) and Dr Prichard (*Researches into the Physical History of Mankind*, 3d edit., vol. i., p. 227) have both, to a certain extent, ventured upon a similar one. To condense my arguments, I shall adduce them in a numerical order, as short as possible.

1. Such expressions as ξανθὸς (Μενέλαος), which frequently occur in Homer, in regard to the colour of the hair (this is especially done regarding Menelaus, who has this epithet nearly always prefixed to his name)—as γλαυκῶπις ('Αθήνη) (blue-eyed), applied to Minerva; βοῶπις ('Ηρη) (oxen-eyed, that is, with large eyes), as applied to Juno; ἐϋκνήμιδες ('Αχαιοί) (the well-legged or straight-legged), used with regard to the Achæans by Homer, and which, strangely enough, has been translated by philologists, "well provided with armour on the legs,"—could only exist in a country where they were of frequent occurrence (take the English names of White, Reid (red), Black, Brown, and the German ones of Weiss, Roth, Schwarz, Braun, &c.), and where, in consequence of the opposite peculiarities being perhaps as frequent, they were as generally understood. Now all these peculiarities, *fair hair*, *blue eyes*, *large eyes*, *straight legs*, belong exclusively to the Teutonic variety; consequently there must have been Teutonic blood circulating largely in the veins of the ancient Greeks.

2. Not to mention the language (which is evidently a mixture of *Celtic* and *Teutonic*, the latter prevailing in the inflexional forms, as well as in the roots and in the whole structure), let us compare their manners, customs, dispositions, and general turn of mind, and we shall find the greatest, nay, a surprising similarity between the ancient Greeks and the Teutonic tribes, more especially the Germans generally. I have only to refer the doubtful reader to Ottfried Müller's *Dorians*, the production of a scholar, who had no hypothesis, as that advanced by me, to defend. (*History and Antiquities of the Doric Race*, translated from the German by H. Tuffnell and G. C. Lewis, 2 vols., maps).

3. Skulls found in ancient Greek tumuli, which, compared with those of Teutonic tribes, more especially with the different subdivisions of the German subvariety, exhibit the greatest resemblance between the two.

4. An accurate study of Greek statuary, made in different capitals of Europe, especially at Paris, has given me the most evident proof that the sculptors themselves were aware of a difference of race among the Greeks, as far as exhibited by a different bodily appearance. We find there models of the Celtic and of the Teutonic variety. Hercules *e. g.* and Jupiter are every inch of them Teutonic figures. Not to speak of what probably would be called ideal portraits, let us look at real ones, and we shall find that the most distinguished Greek philosophers, poets, orators, statesmen, had Teutonic heads; compare, *e. g.*, those of Socrates, Plato, Demosthenes, Æschines, Euripides, Æschylus, Pericles, Miltiades, Cimon.

II. *Celtic.* a, Pure.		Gaelic. Erse. Cymrian Welsh. Cornish. Manx. Breton. Basque. Grison.		Western coast and Highlands of Scotland. Interior and western, and greater part of southern coast of Ireland. South and part of North Wales. Cornwall. Isle of Man. Little Brittany. South-eastern part of France, Basque provinces of Spain. Grisons in Switzerland.
b, Mixed.	*Note.*—The name of that subvariety, is constantly placed first, which prevails in the mixture.	Auvergnat. Flamand-Walloon. Cornish-English. Gallic-Roman-Teutonic. Ibero-Celtic-Roman-Teutonic-Moorish. Italic-Celtic-Grecian-Roman-Teutonic-Moorish. Pelasgo-Grecian-Teutonic-Slavonian-Turkish.		Auvergne in France. Southern part of Belgium. Cornwall. Most provinces of France, those above mentioned excepted. Spain and Portugal. Italy, Sicily. Greece and the Grecian Islands.
III. *Slavonic.* a. Pure.		Polish. Wenden. Sorben. Cassubian. Czechian. Russian, (Great and Little). Rusniako. Moravian. Slavonian Proper. Croatian. Montenegrine. Servian. Bosnian. Morlachian. Bulgarian. Arnauto. Suliote.	Slavonian.	Poland, Grand Duchy of Posen, Gallicia. Lusatia, Thuringia. Eastern borders of Pomerania. Bohemia. Russia (Great and Little). North-west of Hungary. Moravia. Slavonian parts of Hungary. Croatian parts of Hungary. Montenegro. Servia. Bosnia. Morlachia. Bulgaria. Epirus, Thessaly. — Turkey. Part of Styria, Carniola, Carinthia
b. Mixed.		Sorbian-Saxon. Czechian-Franconian. Czechian-Saxon. Wallachian-Roman. Illyrian. Dalmatian. Slavonian. — Celtic. Lithuanian-Finnian.		Lusatia, part of Thuringia. North-western part of Bohemia. Moldavia and Wallachia. Illyria. Dalmatia. Confines of Switzerland, Tyrol, and Germany. Lithuania, Livonia, Curonia.

IV. *Finnian* variety of the Mongolian species.

a, 1, Pure.	Finnian Proper. Samoeidian.	Northern parts of Norway and Sweden. North-eastern parts of Russia.
b, 1, Mixed.	Finnian-Northman. Finnian-Gothic. Finnian-Slavonian. Finnian-German.	Coasts of the White Sea, and of the Grand Principality of Finland. North-eastern parts of Russia. Curonia, Livonia, Esthonia.
a, 2, Pure.	Magyar.	Hungary.
b, 2, Mixed,	Magyar-Slavonian.	Hungary, Transylvania, Gallicia.
Letton.	Lithuanian. Letton. Curonian.	Lithuania, Livonia, Curonia.
V. *Turks.*	Turkey.	

VI. *Tartar* variety of the Mongolian species.

Mixed.	Nogaic Tartar. Crimean or Taurian Tartar. Casan Tartar. Meschtscherjärken Tartar. Tartar-Kalmyk-Russian.	Banks of the Kuban and Don. Russian Government of Taurida, Iekaterinoslav. Government of Kasan. Government of Orenburg. Between the Don and Volga rivers.

VII. *Kalmyk* variety of the Mongolian species.

Soonjar Kalmyks. Torgot Kalmyks. Derbet Kalmyks.	Prairies between the Volga and Ural rivers.

It is scarcely necessary to add, as a general remark, that, although the character of every variety and subvariety, pure and mixed, can be sufficiently traced and pointed out, yet there is as great a difference in individuals of the same tribe, in consequence of individual cases of crossing, and increasing civilization, as between animals of the same breed. With regard to the latter, more especially those which are of use to man, or serve for his amusement—as horses, dogs, cattle, &c.—a great deal of accurate knowledge about the peculiarities of species, varieties, &c., has already long existed, and even peculiar care has been taken to improve individual breeds, whilst, although of infinitely more importance, man has been exceedingly careless, and is, consequently, ignorant of the natural history of his own species.

GENERAL FACTS RELATIVE TO THE PHYSICAL CHARACTER OF NATIONS.

I. The physiological character of a nation lasts longer than its language.

Exemplified in the Normans in France, the Lombards in Upper Italy, the inhabitants of the Butt of the Isle of Lewis (one of the Western Islands of Scotland), the inhabitants of several districts of the Scottish Highlands and of North Wales, several parts of modern Greece, the inhabitants of the latter of which are undoubtedly of Slavonian origin, and yet speak Greek, the so-called White Cabyles in the Atlas, who speak an Arabian dialect, although they are a remnant of the Vandals.

II. The same physiological character in two tribes or nations is an indubitable proof of the same origin.

Self-evident, and corroborated by historical accounts of settlements in different countries of Europe. Thus, in several parts of Scotland, you find still the Germans of the north-west of Germany, the Norwegians; and in parts of England the Norwegians, Danes, and Saxons of old; and in Normandy the Norwegians of old,—although the languages spoken in the different countries mentioned vary now to a great extent.

III. Similarity of language in two or more tribes or nations, induces only a supposition in favour of the same origin.

Everybody would, without a knowledge of the physical character of several tribes or clusters of inhabitants in Scotland, Greece, France, suppose they were of the same origin with their neighbours, from their speaking the same language, whilst the fact is, that they have only assumed this language in course of time, according to what seems to be a natural law—namely, that the language of superior development prevails over that of inferior culture, if the numbers of the conquerors are at all in sufficient proportion to that of the conquered nation. This is exemplified by the Teutonic tribes, who conquered Britain, and colonized (in the twelfth and thirteenth centuries) the north of Germany, then possessed by Slavonian tribes; by the Romans in France, Spain, and Portugal; whilst, on the other hand, the Teutonic tribes who invaded Italy, France, and Spain, lost their language for the reasons assigned.

IV. Even in the so-called Caucasian races of the genus Man, there are to be found two distinct shades of complexion, the fair one (Xanthous), and the sallow or darker one (Melanous), each connected with constitutional peculiarities of frame, temperament, and intellect.

Thus the Celtic variety is dark (Melanous), whilst the Teutonic is fair. The Slavonian is in many tribes intermediate between the two.

V. In the crossing of these two shades, the darker one generally prevails over the fairer one in complexion, colour of eyes and hair; the fairer one generally predominates, on the other hand, over the darker one, so far as frame of body, and frequently so far as temperament, are concerned.

Exemplified in the Lombards, Castilians, Catalonians, Arragonians, inhabitants of the Franche-Comté, and of North Germany. In the former the complexion is dark, but the frame of the body is still Teutonic; in the latter (North Germans) the frame is often a mixture of the Slavonian and German, but the darker complexion in the mixture commonly prevails.

Note.—The preceding proposition refers to countries in which the crossing of the Melanous with the Xanthous tribes took place on a large scale. The author is very well aware, however, that in individuals an almost indefinite variety of cross-breeds may be pointed out. To state what proportions of different blood entered into the mixtures which produced the results above alluded to, is almost impossible at the present day.

VI. Increasing civilization exercises a striking influence on colour (not by the crossing of shades alone), and has an evident tendency towards making the darker shade more general.

Illustrated in the inhabitants of the country in several parts of Germany, in which it is impossible to prove that a mixture of blood ever took place on a larger scale, when contrasted with those of the towns (the inhabitants of the towns being darker); and in certain large towns, such as Hamburg, Hanover, Brunswick, Cassel, Frankfürt, not to speak of such as Berlin, Vienna, Munich, Stüttgardt, Mainz, Cöln, in which there is evidently a great mixture of blood.

VII. The Teutonic variety has everywhere, and at all times, been an encroaching one.

In ancient times they continually encroached upon the Celtic nations of the south of Europe. They have spread over North America, conquered India, and are rapidly colonizing Australasia.

VIII. The varieties of mankind seem to have an instinctive consciousness of their natural physical difference, which may, to a certain extent, be overcome by a great degree of mental culture, but which, in primitive conditions, is expressed by a mutual aversion and disinclination for intermarriage. This peculiarity has often been denied by well-meaning but one-sided and abstract-thinking philanthropists; but the whole history of all ages shows it most distinctly to exist.

IX. Climate exercises a considerable influence upon the different varieties inhabiting Europe.

The Teutonic variety, in its different subvarieties, agrees best with a temperate climate; it is, however, capable of bearing a high degree of cold; so is the Slavonian variety. Both seem to prosper best northwards of 45° of northern latitude. Wherever the Teutonic and Slavonian varieties have settled further southwards, as was the case with the former in Spain and Italy, they have lost, to a great extent, their natural vigour, unless the territory in which they lived was considerably elevated above the sea, as is the case with some remnants of the Goths in the Pyrenees, and the White Cabyles in the Atlas. The same may be said of the Slavonian tribes settled in parts of Turkey, Greece, and the south of Russia. But too great a stress must not be laid upon this point, as, in almost all these instances, the Teutonic and Slavonian tribes became mixed with the different subvarieties of the Celtic variety; by which mixture their natural physical character was partly changed. The Celtic variety, on the other hand, seems to agree best with the climate south of 45° northern latitude. Its scattered remnants farther northwards, where they are unmixed, as in Brittany, and some parts of the Highlands of Scotland, in Ireland, and Wales, seem not to prosper so well. The astonishing increase of population in Ireland does not contradict this, as, in Ireland, there is more of Teutonic blood than is generally suspected or admitted (not to mention the peculiar moral causes which have brought about this result). How much climate influences the habits and modes of living of different races, or of different tribes of the same race—how much, at the same time, through the agency of the atmosphere, the mind of human beings is affected, may be learned from Liebig's *Animal Chemistry*.

X. It is natural to suppose that the stream of immigration went first up the rivers, filling first the plains, and afterwards extending to the mountains.

XI. Mountains, more frequently than rivers, are the natural boundaries of nations.

XII. Mountaineers have been far less affected by the influence of the so-called migration of nations, than the inhabitants of the plains; therefore we find among the mountaineers the remnants of the oldest races in Europe.

GENERAL FACTS RELATIVE TO THE INTELLECTUAL AND MORAL CHARACTER OF NATIONS.

I. Most subject to change are—*Form of government*, next *religion*, then *language*.

Exemplified by the history of the different varieties of the Caucasian species for the last 3000 years. The *Celtic* variety in its subvarieties, during this period, has passed through the different stages of political development pointed out by patriarchal despotic power, aristocracy and democracy—both, however, only to a certain extent, attained in Rome—despotic monarchy, feudal monarchy, imposed upon them by the Teutonic tribes; and lastly, representative monarchy, without feudal character. They, from being Polytheists, have become Christians; but, without exception, have remained adherents to that Christian Church which, in admitting saint-worship, partakes still, among the uneducated at least, of the character of Polytheism. The language of all the Celtic tribes in Italy, Spain, Portugal, and France, has been *Latinised* or *Romanised*.

The *Teutonic* variety has undergone several changes in the form of its government, passing from aristo-democratism to feudalism, with representative character; afterwards more or less to absolute despotic monarchy; and lastly, to a superior system of representation, either in the representative monarchy or representative democracy or aristocracy. It has changed from Polytheism to Christianity, and in all its pure branches, in course of time, adhered to the more strictly monotheistic divisions of the Christian Churches (Protestantism). The language has undergone no other change but that of gradual development.

The *Slavonian* variety has passed from patriarchal and democratic beginnings, through aristocracy, to absolute despotic monarchy—a stage of development at which they are at the present day. From Polytheists its different subvarieties have turned to Christianity, which all of them profess in a form more or less favouring the primitive polytheistical dispositions of the people. Language has only undergone with them a very slow development.

II. *Least subject* to change are—The *moral sentiments*, next *habits*, and then *intellectual faculties*.

Thus the French and the Germans have still the same general character which was ascribed to them by the Romans eighteen hundred years ago. The development of the intellectual faculties in a nation depends upon a combination of many apparently accidental circumstances, and may be very high at one time and rather low at another. I have only to refer to the Greeks of old, and to the state that country is in at the present day; to the high state of civilization among the Arabs in Spain in the middle ages, and to the comparative low stage they occupy now; to the Bohemians of the fifteenth century, and to those of the present day; to the English of the times of Henry VIII., and to the industrious active race they are at present. But, upon examining closely, we shall always find that the ultimate development attained was in exact proportion to the natural talents of the nation in question, and the circumstances which brought them into play; so that there is necessity rather than accident exhibited in the general results of the life of a nation.

GENERAL FACTS RELATIVE TO EUROPEAN LANGUAGES.

I. All European languages can be traced back to the Sanscrit (the language of the educated classes, more especially the priests, among the ancient Hindoos), as an approximate common source, from which their peculiarities receive a proper explanation, and in which a solution is found for every phenomenon, to elucidate which there is no clue in any other language.

II. Language is to a great extent something organic, independent of the will or caprice of man. The changes which the different European languages have undergone in inflexion and structure, are greater than the changes which have taken place in the physical and moral character of nations. Not to speak of mixed languages, we have only to look to the pure ones, *e. g.*, the Teutonic ones, for the changes which they have undergone for the last 1500 years—changes which are so great, that it is difficult for the uninitiated to find in the Gothic and Old Saxon the mother of the present German dialects.

III. Palatal and guttural sounds prevail in the language of mountaineers.

IV. Labial sounds prevail in the language of the inhabitants of flat countries, more especially those surrounded by the sea.

V. The vowel system of all languages is less rich (more developed) in the language of the educated classes, than in the dialects spoken by the country people.

VI. There is a law of interchange of consonants relative to all the languages which belong to the same stock. According to this law, we may have in one language, in a word which is of the same origin with another of the same meaning in a cognate language, a different consonant—however, belonging to the same class of consonants to which the consonant in question belongs; *e. g.*, English, ri*d*e, German, rei*t*en; English, bri*d*e, German, brau*t*; English, *death*, German, *tod*; English, *d*aughter, German, *t*ochter; English, slee*p*, German, schla*f*; English, brea*k*, German, bre*ch*en, &c. &c.

VII. The High German and the Icelandic (?) are the only two modern European languages in which the vowels have only one pure distinct sound, whilst in all other languages there are different shades of sound attached to most of them.

VIII. The grammatical construction of sentences, as well as the proper formation of periods, depends, not only on logical, but also upon rhythmical laws, which are peculiar to the different languages.

IX. These laws undergo some changes in course of time,—partly in consequence of the greater development of the languages, and partly in consequence of the languages becoming mixed.

X. Mixed languages, to a certain extent, lose the power of organic life, and their flexibility.

XI. The less developed a language, the richer are its forms of inflexion; the more developed, the poorer.

XII. The languages least developed in the vowel and consonant system among the European languages are the Slavonian ones; but they are richest in forms of inflexion.

XIII. The limits of languages are commonly formed by mountains, as we find in some mountains of the Alps the borders of three languages (German, French, and Italian). Sometimes they are formed by rivers, *e. g.*, in the canton of Freiburg in Switzerland, in the city of Freiburg itself, where the river Sarine forms the limit between the German and French-speaking populations.

XIV. A language cannot be forced upon a nation, unless it be not only superior to that which it is intended to supersede, but also propagated by a superior number in those who intend to force it upon another nation. This, however, holds only good in rude, barbarous times, and in periods of comparatively high civilization, when both nations are civilized. This is exhibited by the vain attempts of the Romans to introduce their language into Germany; by the French to spread theirs in Alsace; and by the Germans to extend theirs over Bohemia. But there is a strange fact on record, that, 150 years after the north of Germany had been conquered by the Germans, and colonized, there was, from the frontiers of Holstein to the river Rega, in Pomerania, scarcely a person to be found who knew anything of the Slavonian language spoken by the former inhabitants of the country. (Compare p. I. III.)

Note.—It is interesting to observe the changes that have taken place in some countries as to the prevailing language. Thus, in the middle ages, Teutonic dialects were spoken in several parts of Belgium to the sea-coast. The very name of the French seaport Dünkirchen (Dunquerque) is Teutonic. The same was the case in Switzerland, where the German extended (in the towns at least) so far as Geneva. In the course of the 17th and 18th centuries, however, in Belgium, as well as the western portion of Switzerland, in the towns universally, and in the country generally (in Switzerland at least), the French has become the predominant tongue. But in the latter country it has only extended so far as the Celtic element of the population reaches.

DISTRIBUTION OF LANGUAGES OVER EUROPE.

I. *Pure.*

a, *Teutonic.* German. (*Hochdeutsch*, the language of the educated classes in all parts of Germany).	a, First Branch: (Mœso-Gothic), *Alemannic, Suabian, Bavarian, Franconian, and Hessian* (*Thuringian*) dialects, spoken respectively in Würtemberg, Baden, Alsace, the German cantons of Switzerland, Bavaria, Hessen-Darmstadt, Hessen-Cassel, the Tyrol, and the German provinces of Austria. b, Second Branch: That of which the most ancient dialects known are the *Anglo-Saxon*, the *Old Saxon*, and the *Frisian*, of which there exist at present, the *Plattdeutsch*, the *Frisian*, the *Dutch*, the *Flamandish*, and the *Broad Scotch*. Spoken respectively in N. Germany, Holland, part of Belgium, and the Lowlands of Scotland.
Scandinavian.	c, Third Branch: That of which the most ancient dialect known is called *Norse* (in the Faröer, and to a certain extent in the Shetland and Orkney Islands), of which there at present exist, the *Icelandic*, the *Danish*, the *Norwegian country dialects*, and the *Swedish*, spoken in the respective countries of which they bear the name.

b, *Slavonian*, comprising the following branches, with numerous subdivisions:—

a, Russian.
b, Polish.
c, Czechian or Bohemian.
d, Cassubian.
e, Sorbian.
f, Servian.
g, Moldavian.
h, Montenegrine.
i, Arnaute.

Spoken in the countries of which they bear the name.

c, *Celtic.* 1, *Gaelic*, spoken in the Highlands of Scotland; 2, *Erse*, by the country people and lower classes in most parts of Ireland; 3, *Kymric*, or *Welsh*, spoken by the lower classes in Wales; 4, the *Manx* (nearly extinct), spoken in some parts of the Isle of Man; 5, *Breton*, spoken in Little Brittany; 6. *Basque*, spoken in the south-west corner of France, by the country people, and in the Basque provinces of Spain.

Note.—The Basque is frequently considered to be quite different from the other Celtic dialects. But, as the inquiry into the peculiarities of this language may still be supposed to have been insufficient, the author ranks the Basque language among the Celtic ones, as the Basques themselves, from all we know of them, must be a Celtic tribe.

d, *Greek*, with comparatively little admixture of Italian and Slavonian, approaching by degrees to the purity of ancient Greek, spoken in Greece. (The ancient Greek, although having, at first sight, the appearance of a pure tongue, was a mixture of Celtic and Teutonic elements).

e, *Finnian*, to be subdivided into different dialects, according to the countries inhabited by that subvariety of the Mongolian variety, and Magyar, or Hungarian, spoken in the country of which it bears the name.

f, *Tartar*, comprising the Crimean, Casan, Kirghis, and other Tartar dialects, spoken in the governments of the Russian Empire, which bear their respective names. The Turkish is a mixed Tartar dialect, spoken by the inhabitants of Turkey.

II. *Mixed.*

a, *Teutonic* prevailing; English, in Great Britain, and among the higher classes of Ireland. (United States of America, British colonies).

b, *Latin* prevailing, with an admixture of numerous Celtic dialects, according to the different subvarieties of the Celtic variety; Italian, French, Spanish, Portuguese, Wallachian, Romanic dialects spoken in the mountainous parts of the French cantons of Switzerland, and in part of the Grisons.

RELIGION OF THE DIFFERENT VARIETIES.

GENERAL FACTS.

I. All the different varieties of the Caucasian species (even out of Europe) profess Monotheism.

II. Christianity has been spread through the agency of the Teutonic tribes, and is as yet confined to those countries to which their influence has extended.

III. According as the natural organisation of the tribes constituting the Caucasian species is more or less favourable, they entertain more or less elevated notions of the Deity.

IV. Although the whole of Europe now, with the exception of a small portion of the inhabitants of the coast of the White Sea, confesses Christianity, yet the more spiritual mode of Christian worship is confined to the nations of Teutonic origin, whilst the more sensuous one, approaching to Polytheism, is universally practised among the Celtic and the Slavonian nations.

V. The Reformation, the principle of which was *self-inquiry*, which is the natural consequence of the prevalence of the reflective faculties in man, and of an independent mind—of liberty in general—has on account of its very nature and spirit, been confined to the nations of Teutonic origin.

A.—*Monotheism.*

a, Christianity.

I. Teutonic, when pure, *Protestant*, only in some parts, as on the Rhine and in the south of Germany; and when mixed with prevailing foreign elements, *Catholic.*

Protestant.

a, With aristocratic-monarchical principles of church government, patronage being vested either in individuals or corporate bodies: Lutheran Church, Episcopalian Church, United Lutheran-Reformed (Presbyterian) Church.

Lutheran Church: Sweden, Norway, Denmark, parts of Finland, Curonia, Esthonia, Livonia, Saxony, Hanover, Hamburg, Lübeck, Bremen, Frankfürt, Würtemberg, Hessen-Darmstadt, parts of Bavaria, Transylvania, part of Hungary.

Episcopalian Church: England, Ireland, and partially in Scotland (United States of North America, and in the British colonies).

United Lutheran and Reformed (*Presbyterian*) *Church*, commonly called *Evangelical:* Prussia, Nassau, Baden.

b, With democratic principles of church government, patronage being vested either in individuals or corporate bodies; Presbyterian (and Reformed) Church; Scotland, Holland, the German cantons of Switzerland, Hessen-Cassel, Geneva, Vaud, part of Vallais, Neufchatel.

c, With democratic principles of church government, patronage being vested in the congregation: Sectarian churches upon the Voluntary principle; Britain (U. S. of America): Antibaptists, Antinomians, Antisupernaturalists, Antitrinitarians, Arians, Arminians, Athanasians, Baptists (General Particular Unitarians or Old Baptists), Baxterians, Bible Christians, Biddelians, Cameronians, Chartist Church, Dunkers or Tinkers, Dualists, Ebionites, Friends (Quakers), Hopkinsian Calvinists, Humanitarians, Hutchinsonians, Independents, Johnsonians, Kithamites, Methodists (Armenian, Calvinistic, Independent, Unitarian), Millenarians, Mormonites or Latter-Day Saints, Muggletonians, Nazarenes, Necessarians, Pædobaptists, Pandelphian Quakers, Pelagians, Quietists, Ranters, Relief Church, Sabbatarians, Sabellians, Sandemanians, Seceders, Shakers, Socinians, Southcottians, Sublapsarians, Supralapsarians, Swedenborgians, Unitarians, Universalists, Winchesterians, Wroëites; few or none on the Continent of Europe; among those tolerated on the Continent, and more extensively spread, are the Moravian Brethren, and the Mennonites.

II. *Celtic, without exception, Catholic.*

Catholic.

With aristocratic-monarchical principles of church government, patronage being vested either in individuals or corporate bodies; a, Church of Rome; Belgium, France, Italy, Spain, Portugal, Austrian Empire, greater part of Bavaria, part of Würtemberg, Baden, Hessen-Cassel, and Hessen-Darmstadt, Prussia, Rhenish Provinces, Poland, Hungary.

b, *Greek* Church: Russia, Moldavia, Wallachia, part of Servia, Greece.

III. *Slavonian*, Greek and Catholic.

IV. *Finnian*, Grecian Church, and among the Lappons, Finnians, and Quänians, also Lutheran-Protestants.

V. *Magyar*, Catholic Church.

VI. *Tartars*, the Grecian Church and Mohammedanism.

b, Islamism; Turks, and some hordes of the Tartars.

B.—*Polytheism;* Some of the Finnian tribes, as Samoeides, Lappons, Quänians.

VII. *Kalmyks:* Lamaism and Schamanism.

POLITICAL CONSTITUTION.

GENERAL FACTS.

I. The Teutonic tribes have, in course of time, developed the different forms of *Representative Government* in the representative Monarchy and Republic. Representation was unknown among the nations of antiquity. Among the Teutonic tribes there are, at present, only the following four Swiss cantons in which representation, in the commonly received sense, has never been known—viz., Uri, Schwyz, Unterwalden, and Zug. In these cantons, all grown-up men form what is called the *Landsgemeine* (meeting of the country), in which is vested the legislative power.

II. The Celtic variety, in its highest development, in the *Roman typus*, has, after having gone through the different stages of a more or less aristocratic republic, closed with *despotic monarchy*, and a code of laws which, however finished in form, in consequence of the proceedings connected with it, and the fictitious principles upon which it is based, is wholly subversive of liberty. To the adoption of this system of laws by the States of the Continent, more especially the German empire, it is owing, to a great extent, that these nations have lost the liberty enjoyed by their forefathers. In England, where Teutonic freedom has lasted longest, and never was entirely shaken, the Roman law never gained a footing.

In modern times, the highest typus of the Celtic tribes, *the French*, have, in their revolution of 1789, *proclaimed* the principles of universal equality, and unrestricted political liberty; they have, first of all Continental nations, re-introduced the ancient Teutonic system of judicial proceedings, publicity and trial by jury; but they have not yet succeeded in establishing civil liberty in their own land.

III. The Slavonian variety has not been able to emerge from a state of internal slavery, although it has shaken off the yoke of foreigners (Tartars), and for the last hundred years has, in Russia, obtained a very powerful representative.

IV. The Magyar subvariety of the Finnian variety has, in its higher classes, shown for ages a spirit of great independence, and individual liberty.

I. *Teutonic variety: Representative* (*limited*) *Monarchy;* Sweden, Norway, Britain, Holland, the so-called Constitutional States of Germany—that is, Baden, the two Hessias, Bavaria, Würtemberg, Saxony, the Saxon Duchies, Mecklenburg, Hanover, and the smaller German States.

Absolute (*unlimited*) *Monarchy:* Denmark, Prussia, Austria (having all of them provincial states of a merely local character, and with a consultative vote).

Aristocratic Republic: Free and Hanse towns of Germany: Hamburg, Lübeck, Bremen, Frankfürt.
Democratic Republic: German Cantons of Switzerland (out of Europe, the U.S. of N. America).
Prevailing Political Spirit: Representation.

II. *Celtic variety.*

1. Representative limited Monarchy (adapted from the Teutonic tribes): in Belgium, France, Spain, Portugal, and Greece; Neufchatel, with the King of Prussia for a hereditary first magistrate.
2. Absolute or unlimited Monarchy: in Italy.
3. Democratic Republic: Cantons of Geneva, Vaud, Valais.
4. Aristocratic Republic: Canton of the Grisons, Ionian Islands, under the protectorate of Great Britain, and S. Marino in the Papal States.

III. *Slavonian variety.* (Lettons included.)

1. Absolute Monarchy everywhere, with the exception of the Republic of Cracow, which has an aristocratic constitution, but is, in fact, ruled by the Resident Ministers of the three so-called protecting powers, Austria, Prussia, and Russia.

IV. Finnian variety.

1. Absolute or unlimited Monarchy: Finnia Proper, the country of the Samoeides, and also in Curonia, Esthonia, Livonia, where indeed there are old representative constitutions, which, however, cannot prevent the monarch from carrying out his pleasure.
2. Representative Monarchy, with a powerful Aristocracy: Hungary.

Turk, Tartar, and Kalmyk variety of the Mongolian division: The two latter Nomadic—*Patriarchal system, and* in Turkey *Absolute Despotic Monarchy.*

Liberty of Press: Repressive measures of more or less rigour, either according to a particular system of laws upon the subject, or in consequence of the application of the articles of the common law on injuries, offences, &c.:—*Great Britain, Norway, Sweden, Holland, Belgium, France, Switzerland, Spain, Portugal, and Greece.*

Preventive measures by means of Censorship: Denmark, Germany, Russia, Italy, Hungary.

Publicity of Judicial Proceedings and Trial by Jury (Teutonic system): *Great Britain, Belgium, France, Rhenish Prussia, Rhenish Hessia, Rhenish Bavaria, Greece. A certain extent of Publicity without Jury:* several cantons of *Switzerland, Norway, Sweden.*

Secret Tribunals and Proceedings exclusively on Paper (Roman system): *Denmark, Holland, Germany* (with the three exceptions mentioned), *Hungary*, several cantons of *Switzerland, Italy, Spain, Portugal, Poland, Russia.*

GENERAL CONCLUSIONS, MORE OR LESS OF A PRACTICAL NATURE, TO BE DRAWN FROM ALL THE PRECEDING FACTS.

I. Every individual, as well as every variety and subvariety of the human race, has certain peculiarities of its own, as regards its physical, moral, and mental organisation.

II. The mental and moral development of every individual and variety of the human race, at any given time of his or its existence, will be in accordance with his natural faculties (mental and moral organisation), and the power of the circumstances which influenced their development; or, in other words, the mental and moral character of every individual, &c., is the result of his organisation, and of the influence exercised upon it by circumstances, and of the reaction of the natural organisation upon these developing circumstances (systems of education, political and religious institutions, position in life, &c.)

III. The result, then, of the intellectual and moral development of every individual, variety, &c., of the human race must be, to a certain extent, different from that of other individuals, varieties, &c.

IV. A nation, in the physical meaning of the word (those political combinations, called nations, being here out of the question), is an organism, consisting of an indefinite number of individual human beings of the same physical and mental organisation, and speaking the same language.

V. As there are natural laws for the organisation of individual man, so there must be natural laws for the growth and decline of nations, although we may not yet be acquainted with them.

VI. As nations are differently constituted, no form of government can be found, which, without material modifications, can be applicable, at the same time, to all of them.

The same, to a certain extent, applies also to religion.

VII. Nations, as well as individuals, can only be developed, to the extent of the powers of their natural organisation, so that even the best institutions, when adopted from abroad, cannot improve a people naturally unfit for receiving them.

VIII. A nation, generally speaking, may always be said to possess those institutions, civil, religious, and political, for which it is fit at the time.

IX. The history of mankind exhibits nothing but the development of the different races, varieties, &c., of the human family, partly apart, and for the last three thousand years as mutually influencing each other; so that a progress in the history of mankind is always indicated either by the appearance of a new stock of people on the stage of the world, or by the produce of a crossing of two races.

X. Nations, as something organic, have to pass through different stages of development. The critical periods of this development are indicated by changes in the form of government and of religious worship. These changes will be violent (Revolution) as long as the natural laws, according to which the development of nations takes place, are not understood by men, or when known, not acted upon; they will be of a harmless character (Reform) when these laws shall be generally understood and acted upon. (Revolution—evolution.)

XI. Nations already about to decay, may be partially regenerated by the infusion of new ideas, or by crossing with other varieties, or by both agencies combined.

XII. In those political combinations, called nations, when of the same origin, living under the same form of government, and enjoying the same general degree of civilization, there will be, in consequence of the same natural influence upon the same constitution, an equal amount of virtuous and vicious disposition. (See Quetelet's excellent work, *Sur l'Homme.*)

XIII. Among the nations belonging to the different varieties of the so-called Caucasian species, there is an evident tendency towards improvement, on an increasing scale. This is fully borne out by the history of the last three thousand years.

Note.—The student is referred, for further illustration of the subject, to *Blumenbach's* "De Generis Humani Varietate Nativâ."—Gotting., 3d Edit., 1795. *Blumenbach's* "Decades Collectionis Craniorum."—Gotting., 1790. *P. Camper*, "Ueber den Natürlichen Unterschied der Gesichtszüge in Menschen verschiedener Gegenden und verschiedenen Alters."—Berlin, 1792. *Virey*, "Histoire Naturelle du Genre Humain."—Paris 1824. *Desmoulin's* "Histoire Naturelle des Races Humaines."—Paris, 1826. *Bory de St Vincent's* "L'Homme."—Paris, 1825. *Edwards'* "Des Caractères Physiologiques des Races Humaines, considerées dans leurs rapports avec l'histoire."—Paris, 1827. *Choulant's* "Drei Anthropologische Vorlesungen."—Leipzig, 1834. *G. Vrolick's* "Considérations sur la Diversité des Bassins des Différentes Races Humaines."—Amsterdam, 1826. *F. M. Weber* "Die Lehre von den Ur—und Racenformen der Schädel und Becken des Menschen."—Düsseldorf, 1830. *R. Wagner*, "Naturgeschichte des Menschen."—Kempten, 1831. *Van der Hoeven* in "Tydschrift voor Naturlijke geschiedenis," vol. i. p. 4. *Cotta's Deutsche Viertel Jahrschrift*, 1838, "Die Menschenracen." *Berthold's* "Menschenracen," im Encyclopædischen Wörterbuch der Medic. Wissenschaften, vol. xxiii., p. 44. *Lawrence's* "Lectures on Physiology, Zoology, and the Natural History of Man." *Morton's* "Crania Americana."—Philadelphia, 1840. *W. Obermüller's* "Atlas Ethno-Géographique, &c. Planche Ethnologique."—Paris and Leipzig, 2d edit., 1842. *J. Müller's* "Elements of Physiology," by Dr William Baly.—London, 1842, vol. ii. *Bernhardy's* "Deutsche Sprachkarte," &c.—1843. "La Science Politique basée sur la Science de l'Homme, ou l'Etude des Races Humaines," &c. Par V. Courtet (de Lisle).—Paris, 1838. (This work contains by far the best reasoning upon the influence which race has exercised on the history of man that is to be found in any book.)—*Dr Prichard's* "Researches into the Physical History of Man." *Dr Latham's* "Varieties of Man," and edition of the "Germania" of *Tacitus.*

ETHNOGRAPHIC MAP OF GREAT BRITAIN AND IRELAND.

Great Britain and Ireland are inhabited by a population belonging to two different varieties of the Caucasian type—the *Celtic* and the *Teutonic*. In the Map, the blue tint indicates the Celtic, and the yellow the Teutonic; while various shades and blendings of these point out the mixtures, and the resulting subvarieties. The names in Saxon letters indicate the localities of the ancient British tribes noticed by the Romans.

I.—CELTIC VARIETY.

I. The *Gaelic* subvariety of the *Celts* inhabiting the greater portion of the Highlands and the Western Islands of Scotland, although it has maintained its original language, has become so greatly mixed in course of time, that it will be impossible to assign to it a specific and physical character. applicable to all the inhabitants of the different parts of the country just mentioned. To use the words of Dr M'Culloch, as one of the best authorities on the subject ("Highlands and Western Isles of Scotland," vol. iv., p. 294), "The original Celtic breed has been modified by the Gothic (Teutonic) blood in these several manners:—By the Picts, by the Belgic-Dalriadans (?), by the early Norwegians and Danes in the north, by the Danish Vikingr and the Norwegian government of Magnus Barefoot, and by the intercourse during a long period between the Irish Ostmen of Dublin and of that eastern coast and of the western of Scotland. Subsequently, and during the same period, that of the Highland Magnates, at least, has been modified by the settlements of Anglo-Normans, Anglo-Saxons, Flemings, and Low-Country, or Saxon, or Pictish Scots."

It is singular that, notwithstanding the excellent treatise on the "Origin and Races of the Highlanders," published by Dr M'Culloch, in the 4th volume of his "Highlands," twenty years ago, the subject of the nature and origin of the Highland population should still be so generally misunderstood. It is scarcely possible to meet with a Highlander who is not proud of his Celtic origin, and pure descent; although nature, with undeniable distinctness, has expressed in his stature, and very frequently in his blue eyes and fair hair, that he is of true Teutonic origin. There is scarcely any other population in any country extant with regard to which such mistakes are daily committed concerning its origin; and those not by strangers, but by the very people themselves. It has already been shown that similarity of language does not constitute an indubitable proof of the same origin among people in a country which is inhabited by different races. It is not intended to go through the whole of the arguments brought forward by the writers on the subject of the origin and race of the Highlanders of Scotland. It is sufficient to refer to Pinkerton, M'Culloch, and Dr Clement ("Die Nordgermanische Welt," &c., Copenhagen, 1840), Fallmerayer ("Geschichte des Kaiserthums von Trapezunt," München, 1827), to leave no doubt where the truth of the question lies. But every one acquainted with the Highlanders may examine the different points bearing upon this inquiry for himself. He will then find that the higher classes of the inhabitants in the Highlands have either the distinctive marks of pure Teutonic origin, viz., large tall figure, blue eyes, and fair or reddish hair; or that they bear, at least, the distinctive marks of a cross-breed, in which the Teutonic character prevails in the frame of body, and often, also, in the occurrence of bluish or grey eyes, although hair and complexion may be dark. (Compare, also, the Gartmore MS., quoted by M'Culloch, vol. iv., p. 255, which says on this subject, "*The principal people being larger-bodied than the inferior sort.*") Among the lower classes in the islands, as well as on the mainland, a great many individuals of pure Teutonic character also occur; the majority there being undoubtedly a cross-breed, in which, on the whole, the *Teutonic* character prevails. Every one who has gone through the Highlands, or examined one of the so-called Highland regiments, of which most of the men are Highlanders, will acknowledge the correctness of this statement. The Highlanders, in short, are far more Teutonic than they themselves know or will acknowledge. They are, in every respect, far more nearly allied to their Saxon Lowland neighbours than to any Celtic race that is extant in its former purity—such as the people in Cornwall, Little Brittany, the Auvergne. In maintaining this point, which is fully brought out by undeniable facts, the author is neither prejudiced in favour of the one nor the other race. He knows full well what great nations the Celtic race has produced; but he is also aware of the fact, that the *pure* Celtic nations, for the last two thousand years, have been on the decline, and that the whole modern civilization of the world, since the establishment of Christianity, is owing to the Teutonic race.

II. The *Manx* subvariety, inhabiting the Isle of Man, which is only quoted here as a separate subvariety, as it formerly had, and, to a certain extent, still has, a language distinct from other Celtic tribes—which, however, stood more in the character of a particularly marked dialect than as a separate language, such as the Welsh and the Irish of the present day. Even in the Isle of Man, in consequence of the Norwegian rule, which lasted for several hundred years (from the seventh to the middle of the thirteenth century), a sprinkling of Scandinavian (Teutonic) blood is to be found in most parts of the island.

III. The *Erse* or *Irish* subvariety, inhabiting the greater part of Ireland, and being spread by immigrations over most of the manufacturing districts of England and Scotland. It would be idle to expatiate here on all the hypotheses that have been advanced regarding the origin of the Irish—whether Phœnician, Milesian, or Iberian—because that point, most probably, will ever remain unsettled. The special character of this subvariety, beyond the general character of the variety, is as difficult to state as that of the *Gaelic* in the Highlands of Scotland; as here in Ireland, too, there have been immigrations of Teutonic tribes, and consequent mixture of races, from a very early period—the circumstances connected with which will be mentioned afterwards. Here only a few names may be given. The original inhabitants of the country were partly conquered and crossed,—1. By *Teutonic Belgæ* from Gaul and England, who settled in the south 300 (?) years before Christ. 2. By *Scandinavian* or *German Scythæ* (*Scots*) in the *north*. 3. By *Picts* in the east. 4. By *Norwegians* and *Danes* in the east and south;—in short, in almost all parts of the coast. 5. By *Anglo-Normans* in the east and north. 6. Colonized by *Englishmen* in Londonderry. 7. By *Lowland Scotch* in Ulster. From this it is evident that there is a great deal, not only of pure, but also far more of mixed Teutonic than of Celtic blood in Ireland; the latter, indeed, occurring in almost all parts of the country—the western and south-western country perhaps excepted. Yet Ireland is far less assimilated to the Saxon race (Teutonic) than the Highlands of Scotland, or almost any other extensive part of Britain, inhabited by an originally Celtic population. It has been said, "Ireland has not been sufficiently conquered." So far as this refers to a crossing of the races, which is always the ultimate result of conquest, it is true. But it is undeniably true, also, that the spirit of resistance, and often of rebellion against England, has proceeded more from the Teutonic, or at least the mixed population, than from the real Celtic stock of the country.

IV. The *Welsh* subvariety, occupying the different counties of Wales. It is probable that, at an early period, a Teutonic colony found its way to Wales (Belgæ ?) which improved upon the original stock of people, and from which the blue eyes of a great many people in North Wales may be derived, as well as the decided resistance which the Welsh opposed to the Saxon invaders at a later period explained. (M'Culloch, vol. iv. p. 281.)

V. The *Cornish* subvariety, inhabiting Cornwall and the Scilly Islands. Whether these people came from Phœnicia, as some believe, or from Spain, or from the opposite coasts of France, it seems, at the present day at least, impossible to settle. They are, in their appearance, far more purely Celtic than any of the other Celtic populations of Britain, taken as a whole. Yet their ancient tongue became extinct at the beginning of the last century.

It is scarcely in place to mention here, after the other Celtic subvarieties, the *Romans* also, as a constituent element of the population of the British Islands. It is true the Romans held Great Britain, or at least the greater part of it, for about five hundred years (50 B.C.—426 A.D.); but as the Roman element in this country was merely represented by armies, which, to a great extent, were composed of foreigners, frequently even of Teutonic origin, and not of Roman, we can scarcely attribute great weight to their stay in this country, in so far as it might have influenced the physical and moral nature of the population. Of their language nothing has remained, as is evident from the Teutonic purity of the so-called Anglo-Saxon; and what is now found of Latin origin in the English tongue must be traced to a far later importation, viz. by the Normans, and still later from the French. By looking into English books written about three hundred years ago, every one may convince himself that at that time the English language was more Teutonic that at the present day, great numbers of Frenchified Latin words having been introduced into English in the course of the seventeenth and eighteenth centuries.

II.—TEUTONIC VARIETY.

We come next to the TEUTONIC Variety, of which we shall now detail the different subvarieties, in the historical order of their arrival in this country.

I. The (*Irish*) *Scottish* subvariety. This is evidently the oldest Teutonic colony in the United Kingdom, occupying, at a very remote age, the whole north of Ireland (Ulster), and swaying over the neighbouring Celtic tribes. They had come from Scythia—*i. e.*, Scandinavia—(see below), according to *Nennius* (Hist. Brit. cap. v.), about 1700 (?) years before Christ. But whatever may have been the actual period of their arrival in Ireland, we have sufficient evidence from ancient writers (Pinkerton, vol. i. pp. 116, 117), that they were anterior to the Picts. For their Teutonic origin, besides the testimony to be found in the circumstance that they came from Scythia, we quote from Clement (p. 27) the following arguments:—1. They came from the north. 2. They came by sea in a fleet (Annals, iv. Mast. 3500). 3. The names of their leaders are Teutonic. 4. They are on friendly terms with the Picts on their arrival (see below, and Bede's Hist. Eccles. Angliæ, i. 1). The subject is also discussed at full length by Pinkerton, (vol. ii. p. 45, ff.) The name of *Scot* is no doubt the same with *Scyth*(ian). Every philologist knows, that the nature of vowels is very changeable, and that there is a regular interchange of consonants of the same class in words of different languages of the same origin, as well as in words of the same language at different periods of its development. Thus we find in ancient MSS. (Pinkerton, vol. ii. p. 47), *Scytic* for *Scotish*, and in the Latin writers of the middle ages Scothi, instead of Scoti or Scotti, in the same manner as in ancient writers there occur *Gottones, Gyttones, Guttones, Gothones*, &c., for the Goths. Thus Scottish and Scotland are indicative of the origin of the race, and synonymous in meaning with Scandinavian, as it is literally with *Goths*, the sibilant S being in many instances dropped in words in two languages of the same origin, or in dialects of the same language, or in the same word at different periods of development of the same language. Compare the German S(ch)*winge*, and the English *wing*; S(ch)*wach*, and *weak*, &c. How the Irish Scots came to invade Scotland (from 258 and 503 A.D.) (the country which afterwards received their name), will be found fully and ably discussed by Pinkerton (vol. ii. chap. 2 and 3, p. 61, ff.); also the question of the nationality of Kenneth, who united the Scots (Dalriads) and Picts, (p. 158, ff.)

II. The *Belgian* subvariety (*Firbolges*), who had settled in the south of Britain not long before Cæsar made the first expedition to this country (300 B.C.?) That these *Belgæ* were of Teutonic origin is settled beyond doubt by his stating them to have been "Plerosque Belgas esse ortos a Germanis." (*Vide* Bell. Gall., lib. ii.)

Tacitus (Vit. Agric., cap. xi.) also states, with regard to them: "*Gallos vicinum* solum occupasse credibile est;" which corroborates Cæsar's statement of the Teutonic origin of the *Belgæ*. Even at the present day that part of the Continent inhabited by the Belgæ consists, to a great extent, of inhabitants of Teutonic origin. It is probable, but by no means yet established by sufficient historical evidence, that the Belgæ sent a colony to North Wales, and another to the south of Ireland. (M'Culloch, vol. iv. p. 281, ff.)

III. The *Caledonian* subvariety. This name may be allowed here for want of sufficient evidence as to what subvariety of the Teutonic variety the inhabitants of Caledonia (ancient Scotland north of the Spey and Inverness) belonged, who are, by the testimony of Tacitus, said to have been people of Teutonic character (see Tacitus, Vit. Agric. cap. xi.): "Habitus corporum varii atque ex eo argumenta, namque *rutilæ* Caledoniam inhabitantium *comæ, magni artus*, Germanicam originem asseverant." Whether these people were *Picts* (see IV. subvariety), or whether they belonged to any other of the many Teutonic tribes which in ancient times—probably long before the Christian era—invaded Britain, it is difficult to decide. From what follows we may conjecture them to have been Picts.

IV. The *Pictish* subvariety. The best work on this subject is Pinkerton's History of the Picts ("An Inquiry into the History of Scotland preceding the reign of Malcolm III.," &c., by John Pinkerton: Edinburgh, James Ballantyne & Co., 1814, 2 vols. 8vo), who, to any unprejudiced mind, must be considered to have settled the question as to the Teutonic origin of this people. We quote only a few arguments in favour of this origin:—1. A great many names of the Pictish kings are evidently Teutonic, only a little disfigured by Celtic terminations. Such names are, among others, Canut (Ganut), Combust, Gere, Thoran, Garnard, Drust, Dunevald (Donivald), Gorm (Gyrum), Brude, Indulf, Luthren, Erp, Amfrude, Uwen, Urupe, Gote, &c. 2. *Beda* (Hist. Eccles., lib. i., cap. 1) and *Geoffrey of Monmouth* (Britanniæ Utriusque Regum et Principum Origo, &c. lib. i., cap. 1), both mention that the Picts came by sea from Scythia. SCYTHIA, as is well known, applied in ancient times to all those countries in the north, and especially north-east of Europe, north of the Black Sea, which were inhabited by nations of Teutonic and Slavonian origin. It is often used synonymously with *Sarmatia*. But from Jornandes down to a late period of the middle ages, it applies distinctly to *Scandinavia*. As the Picts thus came from Scythia by sea, we have only the alternative of tracing them from people of *Teutonic* or of *Slavonic* origin. The Slavonian tribes have never been distinguished for their maritime skill nor for their piratical expeditions. Both, however, was the case with all the Teutonic tribes of Northern Europe. Further, we do not find the least trace of any Slavonian settlement in this country. We therefore may, without being accused of rashness, conclude that the Picts were a tribe of Teutonic origin. From what part they came, it will be impossible exactly to ascertain. But if we may judge from the appearance of the people in those parts of Scotland (Lowlands) which are undoubtedly inhabited by the descendants of the ancient Picts, and if we further turn to account the testimony of the language of the Lowlands of Scotland, we may perhaps be entitled to infer that the greater mass of these Picts must have come from the coasts of Germany (and, perhaps, of Denmark) bordering upon the North Sea. Both authors (it is, however, probable that Geoffrey of Monmouth merely copied from Beda, as was done very frequently in the middle ages) further mention, that the Picts came to that part of Scotland which we already, in Tacitus' time, find inhabited by a Teutonic race (see above), after first having gone to the north of Ireland, already inhabited by the Scots, and there been refused admittance. Our authorities further state that the Picts, who had no women with them, got wives from the Scots in Ulster, as the Britons were not willing to give them their daughters. In the following circumstance there is another argument in favour of the Teutonic origin of the Picts. 3. The whole Lowlands of Scotland are inhabited at the present day by a Teutonic race, of which we cannot trace the origin to any known immigration of Teutonic colonies. It is, therefore, natural to suppose that the Lowland population is actually the offspring of the ancient Pictish population, as the Picts, after having first settled in the north and north-east of Scotland, came, in course of time, to possess themselves of the southern portion also. But it is said: If the Picts were of Teutonic origin, how did it happen that they were vanquished by the Scots from Ireland, who, from all that we know, must have been Celts?—but we know as well that the Celts in the long-run were always beaten by the Teutonic tribes—How, then, should a Teutonic race, in this instance, have surrendered to a Celtic one? Further: If the Picts were a people of such consequence, as is frequently asserted, how did it come to pass that their very name has entirely disappeared? Both these questions can be easily, and, we think, satisfactorily answered. 1. The Picts were conquered (if conquered at all, which is more than doubtful—see Pinkerton, vol. ii. p. 160, ff.) by a kindred race, the Scots from Ireland (Dalriads); these Scots or Skyths being undoubtedly not Celts, (see above.) 2. Pinkerton, M'Culloch, and Clement, have answered the second question by referring to the analogous case of the name of England, which is derived from the Angles, who evidently formed a very small portion of the Teutonic invaders of Britain, the great majority of them going by the name of Saxons. We may further add, as a proof of the strange fate of the names of nations, that at the present day the descendants of a Teutonic race call themselves, notwithstanding—"BRITONS" (as inhabitants of Great Britain), although they have nothing at all in common with the ancient Britons of this country.

It is another question to fix the date when the Picts came first to this country, as several immigrations of them in succession seem to have taken place. We agree with Pinkerton (see vol. i. pp. 207, 208) that the first colony of them may be supposed to have come about 200 or 300 years before the Christian era.

To explain how the Picts came to spread over the whole Lowlands of Scotland, and over the counties south and south-east of the Grampians, would lead us too far away from our purpose, which was simply to vindicate their Teutonic origin.

V. The *Anglo-Saxon-Jutian-Frisian* subvariety, conquering and filling, since the middle of the fifth century, first under Hengist and Horsa, gradually the eastern, southern, and even midland counties of Great Britain. More correctly, perhaps, the *Angles*, the *Saxons*, the *Jutes*, and the *Frisians*, should be classed apart, as we know that they settled in different localities; as the Jutes in Kent, A.D. 449; the South-*Saxons* in Sussex, A.D. 491; the West-*Saxons* in Hampshire, Dorset, A.D. 519; the East-*Saxons* in Essex, &c., A.D. 527; the East-*Angles* in Norfolk and the neighbouring localities, A.D. 527; in Northumberland (Bernicia), A.D. 547; Yorkshire (Deira), A.D. 559; in Derbyshire (Mercia), A.D. 586. However, it is more than probable that even from the very beginning these invaders did not consist of distinct bodies, composed of individuals merely of the same tribe; but that, on the contrary, they were afterwards, like the Normans, composed of people of almost all the Teutonic tribes bordering upon the North Sea.

VI. The *Northman* subvariety, occupying, since the beginning of the eighth century, the Western Isles of Scotland, the Orkney and Shetland Islands, and ravaging and conquering parts of the north east coast of Scotland, and of the north and north-east coast of Ireland.

VII. The *Danish* subvariety, for more than a hundred years (from the end of the eighth century) omnipotent in England and Ireland; making descents, and establishing settlements on the eastern coasts of Scotland; in Northumberland, Yorkshire, and the whole south of England; and the south, principally the east, of Ireland.

VIII. The *Norman* subvariety. This subvariety (if this designation is at all appropriate here, as the Normans who came from Normandy were Scandinavians, mixed with Frisians, and other adventurers from the German coasts of the North Sea) offers the extraordinary phenomenon in history of having given up its original language within the course of 150 years (912-1066) after it first permanently settled in Normandy, and before it conquered England, for a mongrel language, composed, for the greater part, of French. This was that Teutonic subvariety which, after the battle of Hastings (1066), took permanent possession of Britain, introduced the feudal system, at that time not known in this country, in the strict sense of the word, and exercised great influence over the destinies of the other allied races over which it became predominant.

This *Norman* subvariety of the Teutonic variety has, at the same time, been the last enemy which Britain saw on its shores, and to whom the inhabitants had to give battle on their own soil.

Since the eleventh century, then, the progress of civilization of the different populations of Great Britain and Ireland, which had begun already several centuries ago, received a new impetus, and continued during the whole of the middle ages down to the present day. It is evident, from all we have said before, that the English people are not an entirely or purely Teutonic race, but that the admixture of Celtic blood has been gradually swallowed up, not only in the midland counties of England, but even in the more western counties—Wales, of course, especially the southern part of it, excepted—so that we may fairly assert that whilst the inhabitants of the eastern and northern counties are (with very slight local exceptions perhaps) entirely Teutonic, the mass of the English people, and of the Lowlands and the eastern coasts of Scotland, is a cross-breed, with four-fifths, at least, of purely Teutonic blood. It has taken hundreds of years ere this intelligent, active, persevering, industrious race of Britain has come forth out of this process of mixture which was going on during the middle ages, and ere that fine race of human beings has been formed for which Britain is so justly famed. Every one who has seen the principal countries of Europe will unhesitatingly admit that no finer men can be found than in the middle and higher classes of Britain; whilst female beauty, at least in England, is found inherent in individuals of all classes of society.

Note.—A pretty sure indication as to the origin of the first Teutonic settlers in most parts of England, and certain parts of Scotland, is given in the nature of the names of the localities (towns, &c.) in which they settled—certain terminations of such names being peculiar to certain Teutonic tribes. The most common terminations of Teutonic places in England are—*ton* (toun), *ham, by, thorpe* (tharp), *bury* (borough and brough), *forth, worth, wich, bridge, ey* (ea), *mouth, burn, dale, field* (Norse, *fiall*; in English frequently *fell*), *thwaite*. (See Clement's "Nordgermanische Welt," p. 195.) Of these, the following are of *Scandinavian* and *Frisian* origin—*ham, by, field* (fell), *thwaite, wich* (wick); of *Saxon*—*ton, forth, wich* (wick), *worth*; common to all Teutonic tribes—*thorpe, bridge, ea, bury* (borough, burgh), *mouth, burn, dale*. The best information on Anglo-Saxon names of localities is to be found in H. Leo., "Rectitudines Singularum Personarum," &c.: Halle, 1842. For common reference may be quoted Gibson's "Etymological Geography:" Edinburgh, Black, 1840. Clement (p. 196, ff) gives a very extensive list of names of English, and also Scotch localities, terminating in *ham, by, fell, thwaite*, &c. See also Leo., "Rectitudines," chap. Die Angelsächsischen Ortsnamen, pp. 1-104.

If we were to make an *average* calculation as to the ethnographic quality of the blood in the population inhabiting Great Britain (for an accurate calculation will, for the present at least, be out of the question), we would most probably arrive at the following result:—

I. *Pure Blood.*

1. Teutonic in England, Scotland, and the east and north-east of Ireland, .	10,000,000
2. Celtic in Cornwall, Wales, the Scottish Highlands, and Ireland, .	6,000,000
	16,000,000

II. *Mixed Blood.*

1. *Teutonic* (that is, with prevalent Teutonic character) in England, Scotland, and the east and north-east of Ireland, ...	6,000,000
2. *Celtic* (that is, with prevalent Celtic character) in Cornwall, Wales, the Highlands of Scotland, and Ireland, ...	4,000,000
	10,000,000
Total of *Teutonic*, pure and mixed, . . .	16,000,000
Total of *Celtic*, pure and mixed, . . .	10,000,000
Sum total, . . .	26,000,000

Note.—Large towns, which are more or less centres of civilization, will always present (even in countries where the population, generally speaking, is pure—*e. g.*, Copenhagen in Denmark, Christiania in Norway, Stockholm in Sweden, and Amsterdam in Holland—all of these countries being inhabited by a purely Teutonic stock, if we except the Finnian portion of Sweden) a great mixture of races. This is, however, more strikingly apparent in large towns in countries which have a mixed population; so that the averages of measurements, &c., made in such localities will, to a certain extent, differ from those of measurements made in the country. To apply this to our case: *London* has a population in which the Teutonic character greatly predominates, because the whole surrounding country, to a great extent, is purely Teutonic; and the Celtic element has come from a great distance (Ireland, Wales, and Scotland). In *Liverpool*, in consequence of the continual influx of Irish, more especially of the lower classes, the two national elements, the Teutonic and Celtic, may nearly balance each other, the Teutonic having the predominance in the middle and higher classes. At *Birmingham*, and *Manchester*, and *Leeds*, the Celtic population, in consequence of the continued immigration of the Irish, is considerably on the increase. The same is the case in *Glasgow*. In Edinburgh, the Teutonic population, although the surrounding country is almost purely Teutonic, amounts to scarcely more than two-thirds of the whole number of inhabitants. In *Belfast*, the Teutonic population (including, as in the former instances, also those crosses which are more Teutonic than Celtic) has the predominance; in *Dublin*, by far the Celtic. In *Cork*, a good deal of Teutonic blood is to be found; but by far the great majority of the inhabitants are Celts. This applies also to *Limerick* and its neighbourhood.

III.—DISTRIBUTION OF RACES.

To facilitate a synoptical view of the distribution of the different races over the whole country, we give the following county list of *England*, *Scotland*, and *Ireland*, with the respective population annexed:—

ENGLAND.

1. *Northumberland:*	Anglo-Teutonic-Pictish (?)-Danish-Northman-Scandinavian.
2. *Cumberland:*	Pictish (?)-Teutonic-Danish-Northman-Scandinavian.
3. *Durham:*	Saxon-Teutonic-Danish-Northman-Scandinavian.
4. *Yorkshire:*	Saxon-Anglo-Teutonic-Danish-Northman-Scandinavian.
5. *Westmoreland:*	Pictish (?)-Teutonic-Danish-Northman-Scandinavian.
6. *Lancashire:*	North of Kendal, Teutonic-Pictish (?)-Danish-Northman-Scandinavian. South of Kendal, the race is mixed Teutonic-Celtic.
Isle of Man:	Manx-Celtic, with an admixture of Northman-Scandinavian.
7. *Cheshire:*	Anglo-Saxon-Teutonic-Anglo-Norman-Danish-Scandinavian, with a slight admixture of Briton-Celtic.
8. *Shropshire:*	
9. *Herefordshire:*	
10. *Monmouthshire:*	
11. *Nottinghamshire:*	
12. *Derbyshire:*	
13. *Staffordshire:*	
14. *Leicestershire:*	
15. *Rutland:*	
16. *Northamptonshire:*	
17. *Warwickshire:*	
18. *Worcestershire:*	
19. *Gloucestershire:*	
20. *Oxfordshire:*	
21. *Buckinghamshire:*	
22. *Bedfordshire:*	
23. *Lincolnshire:*	Saxon-Teutonic-Danish (Northman)-Scandinavian.
24. *Huntingdonshire:*	
25. *Cambridgeshire:*	
26. *Norfolk:*	
27. *Suffolk:*	Belgic-Saxon-Teutonic-Danish (Northman)-Scandinavian.
28. *Essex:*	
29. *Hertfordshire:*	
30. *Middlesex:*	
31. *Surrey:*	
32. *Kent:*	
33. *Sussex:*	
34. *Berkshire:*	
35. *Wiltshire:*	
36. *Hampshire:*	
37. *Dorsetshire:*	
38. *Somersetshire:*	*Belgic-Saxon-Teutonic-Danish (Northman)-Scandinavian, with a slight admixture of Celtic.*
39. *Devonshire:*	
40. *Cornwall:*	*Cornish-Celtic, with a slight admixture of Saxon-Teutonic-Danish-Northman-Scandinavian.*
Scilly Islands:	Cornish-Celtic.

Note.—See VIII., Teutonic subvariety.

WALES.

1. *Anglesey:*	Celtic (Welsh)-Cymric-Belgic (?)-Northman.
2. *Caernarvon:*	Celtic (Welsh)-Cymric-Belgic (?).
3. *Denbigh:*	
4. *Flint:*	
5. *Merioneth:*	
6. *Montgomery:*	
7. *Brecon:*	Welsh-Celtic.
8. *Carmarthen:*	
9. *Cardigan:*	
10. *Glamorgan:*	
11. *Pembroke:*	
12. *Radnor:*	

SCOTLAND.

1. *Wigtownshire:*	Pictish-Teutonic-Celtic-Scandinavian.
2. *Kirkcudbright:*	
3. *Dumfriesshire:*	Pictish-Teutonic-Celtic.
4. *Ayrshire:*	Pictish-Teutonic, with a slight admixture of Celtic, with admixture of Danish (?)-Northman-Scandinavian on the coasts.
5. *Renfrewshire:*	
6. *Lanarkshire:*	
7. *Peeblesshire:*	
8. *Selkirkshire:*	
9. *Roxburghshire:*	
10. *Berwickshire:*	
11. *East-Lothian:*	
12. *Mid-Lothian:*	
13. *West-Lothian:*	

SCOTLAND—*Continued.*

14. *Stirlingshire:*	Pictish-Teutonic-Celtic.
15. *Fife:*	Pictish-Teutonic-Scandinavian.
16. *Clackmannan:*	
17. *Kinross-shire:*	Pictish-Teutonic-Celtic.
18. *Dumbartonshire:*	
19. *Argyleshire:*	Gaelic-Celtic-Pictish-Teutonic-Scandinavian.
20. *Buteshire:*	Gaelic-Celtic-Scandinavian.
21. *Perthshire:*	Pictish-Teutonic in south and south-east, Pictish-Teutonic-Gaelic-Celtic in the north and north-west.
22. *Forfarshire:*	Pictish-Teutonic-Danish-Scandinavian.
23. *Kincardineshire:*	
24. *Aberdeenshire:*	Pictish-Teutonic-Danish-Northman-Scandinavian.
25. *Banffshire:*	
26. *Moray:*	Pictish-Teutonic-Celtic-Danish-Northman-Scandinavian.
27. *Nairnshire:*	
28. *Inverness-shire:*	Gaelic-Celtic-Danish-Northman-Scandinavian, the Scandinavian element prevailing on the coasts.
29. *Cromartyshire:*	
30. *Ross-shire:*	
31. *Sutherland:*	
32. *Caithness:*	
33. *Orkney and Shetland:*	Pictish-Teutonic-Danish-Northman-Scandinavian, with an admixture of Celtic.

IRELAND.

1. *Wexford:*	Irish-Celtic-Danish-Northman-Anglo-Norman.
2. *Kilkenny:*	Irish-Celtic-Belgic-Anglo-Norman.
3. *Carlow:*	Irish-Celtic.
4. *Wicklow:*	Irish-Celtic-Danish-Northman-Anglo-Norman.
5. *Dublin:*	
6. *Kildare:*	Irish-Celtic.
7. *Queen's County:*	
8. *King's County:*	
9. *Westmeath:*	
10. *Longford:*	
11. *Meath:*	
12. *Louth:*	Irish-Celtic-Danish-Northman-Anglo-Norman.
13. *Cork:*	Irish-Celtic-Belgic, with admixture of Danish-Northman-Scandinavian.
14. *Kerry:*	Irish-Celtic.
15. *Limerick:*	Irish-Celtic, with admixture of Danish-Northman-Scandinavian.
16. *Tipperary:*	Irish-Belgic-Celtic.
17. *Waterford:*	Irish-Celtic, with admixture of Danish-Northman-Scandinavian.
18. *Clare:*	Irish-Celtic, with admixture of Danish-Northman-Scandinavian.
19. *Cavan:*	
20. *Fermanagh:*	
21. *Monaghan:*	
22. *Armagh:*	
23. *Down:*	Irish-Scottish-Pictish-Teutonic-Danish-Northman-Anglo-Norman-Scotch-Irish-Celtic.
24. *Antrim:*	
25. *Londonderry:*	
26. *Tyrone:*	Irish-Celtic.
27. *Donegal:*	Irish-Celtic-Danish-Northman-Scandinavian on the coasts.
28. *Galway:*	
29. *Mayo:*	
30. *Roscommon:*	Irish-Celtic.
31. *Leitrim:*	
32. *Sligo:*	

Note.—The population of the different counties of Great Britain and Ireland has been pointed out by adjectives, of which those stand first which represent the greater amount of blood of the subvarieties of the *Celtic* and *Teutonic* variety inhabiting them. Those counties of Ireland designated by Irish-Celtic, contain, nevertheless, a good sprinkling of Teutonic blood. This is more especially the case on the coast of the south-western and western counties, where there are often separate small communities to be found (mostly fishing villages) which are entirely of Teutonic, generally Scandinavian, origin.

IV.—DISTRIBUTION OF LANGUAGES.

The language of the inhabitants of the United Kingdom differs, of course, according to the race to which the people belong. We have thus two great stems of languages, viz.—

A. The *Celtic*, closely allied to the Semitic dialects of Asia (see "Dr Pritchard on the Eastern Origin of the Celtic Nations"), and represented in Great Britain and Ireland by the following languages, of which one, the Manx, stood perhaps only in the relation of a dialect:—

I. The *Cornish*, now extinct, but still spoken about the beginning of last century in Cornwall.

II. The *Welsh*, spoken in the whole of Wales.

III. The *Irish* or *Erse*, spoken in the greater part of Ireland.

IV. The *Manx*, spoken in the Isle of Man, but nearly extinct.

V. The *Gaelic*, spoken in the Highlands and Western Islands of Scotland.

B. The *Teutonic*, which exists in the two languages, called—

I. The *English*, spoken by a majority of the inhabitants of Great Britain and Ireland, either as their mother tongue, or at least as the language of business and mutual intercourse.

II. The *Scotch*, spoken by the Lowlanders of Scotland, and the inhabitants of the counties south-east and east of the Grampians, up to Inverness.

Both languages are split into a great many provincial or local dialects. A list of the principal provincial glossaries of the English and Scotch languages is to be found in Dr Bosworth's "Dictionary of the Anglo-Saxon Language." (London: Longman & Co., 1838, p. xxvii., in the note.)

That the *Scotch* is actually a language independent of the English, although of the same stock, and not, perhaps, as supposed by some, a deteriorated English or Saxon, there can be no doubt. But it is not the place here to write a treatise on the subject. Those who have hitherto written on the subject, generally, did not know the German, or at least were quite unacquainted with the country dialects of Northern Germany, and with the historical development of the German language. Any person possessing this requisite knowledge, who chooses to make a comparison between the popular dialects of the north of Germany with those of Scotland, will soon be convinced that the Scotch is not derived from, or, as has been strangely enough supposed, deteriorated out of the English, but belongs, with it, to the second branch of Teutonic languages. (See Notes on Ethnography of Europe—Languages.) Whosoever wishes to form an opinion on the subject, needs only compare the most ancient remnants of the Scotch language with the old English or Anglo-Saxon, and he will at once see the difference. The supposed Danish origin of the Scotch language can easily be explained, from the circumstance of the Danish invasions and settlements in the north-east and east coast of Scotland; in consequence of which a considerable number of Danish words occur in Forfarshire, and other neighbouring counties.

MISCELLANEOUS PHYSICAL STATISTICS.

I.—Measures of Soldiers, and of 562 Civilians residing in Edinburgh, &c.

Average size of about 2000 Infantry Soldiers, measured in the Castle of Edinburgh by Mr Macdonald—viz., two Scotch and one English Regiment.

	42d Royal Highlanders.	71st Highland Light Infantry.	77th Regiment of Foot.
Average of Height, . .	5 ft. 8$\frac{4}{12}$ in.	5 ft. 7$\frac{1}{2}$ in.	5 ft. 7$\frac{4}{12}$ in.
" Head and neck, .	10$\frac{3}{4}$ "	10$\frac{4}{12}$ "	10$\frac{11}{12}$ "
" Body, . . .	25$\frac{4}{12}$ "	24$\frac{11}{12}$ "	24$\frac{4}{12}$ "
" Fork, . . .	32$\frac{4}{12}$ "	32$\frac{4}{12}$ "	32$\frac{4}{12}$ "
" Circumference of Chest,	38$\frac{11}{12}$ "	33$\frac{4}{12}$ "	37$\frac{4}{12}$ "
" " Waist,	32$\frac{11}{12}$ "	33$\frac{4}{12}$ "	32$\frac{4}{12}$ "
" " Hip,	40$\frac{7}{12}$ "	38 "	36$\frac{4}{12}$ "

The above Regiments were measured without their shoes.

Average of Middle and Upper Classes.

Full Height of 562 individuals—

Average, ...	5 ft. 8[illegible]	in.
" Head and neck,	10[illegible]	"
" Body, . .	25[illegible]	"
" Fork, . .	32[illegible]	"

Average of Lower and Middle Classes.

Average, ...	5 ft. 7$\frac{1}{4}$	in.
" Head and neck,	10$\frac{1}{8}$	"
" Body, . .	25	"
" Fork, . . .	32	"

The above were measured in their shoes.

II.—Table showing the Average Circumference of the Chests of the Recruits examined in the London District, from the 13th October 1838 to the 12th January 1839, inclusive, arranged according to the Height of the Recruits. By Henry Marshall, F.R.S.E., Deputy Inspector-General of Army Hospitals.

Height of the Recruits.	Town Recruits.				Country Recruits.				Aggregate.			
	No. examined.	Average size of chest.	No. found fit.	Average size of chest.	No. examined.	Average size of chest.	No. found fit.	Average size of chest.	No. examined.	Average size of chest.	No. found fit.	Average size of chest.
Ft. In. Ft. In.		In dec.		In dec.		In dec.		In dec.		In dec.		In dec.
5 5 to 5 6	83	32.44	53	32.54	23	32.77	20	32.66	106	32.51	73	32.57
5 6 to 5 7	425	32.03	279	32.19	233	32.71	197	32.80	658	32.15	476	32.44
5 7 to 5 8	223	32.24	127	32.53	103	33.11	93	33.13	326	32.52	220	32.79
5 8 to 5 9	122	32.57	79	32.81	56	33.00	47	33.18	178	32.70	126	32.93
5 9 to 5 10	58	32.76	33	32.59	28	33.75	23	33.57	86	33.08	56	33.00
5 10 to 5 11	44	32.54	27	32.94	13	33.61	8	33.81	57	32.77	35	33.14
5 11 to 6 6	20	32.92	10	33.00	3	33.67	2	35.00	23	33.02	12	33.33
And upwards.	4	32.28	1	32.00	1	33.00	1	33.00	5	32.50	2	33.50
	979	32.06	609	32.22	460	32.91	391	32.99	1439	32.47	1000	32.66

III. Average of Measurement of 297 Scotch and Irish reapers, who were measured on the suggestion of Dr George Wilson of Edinburgh, by Charles Stevenson, Esq., Redside, Haddington.

Statement of the average Height, Weight, Complexion, &c., of Men and Women in some of the Counties of Scotland and Ireland.

SCOTLAND.

Counties.	Number.	Height.	Weight.	Colour of Eyes.	Colour of Hair.	Complexion.
		Ft. In.	St. lb.			
Roxburgh,	3 men	5 7	10 4	2 light, 1 dark	3 light	3 light
East Lothian,	30 men	5 9	11 5	23 light, 7 dark	18 light, 12 dark	20 light, 10 dark
Do.	19 women	5 4	8 9	17 light, 2 dark	12 light, 7 dark	15 light, 4 dark
Ayrshire,	2 men	5 9	11 5	Light	Light	Light
Wigtown,	1 man	5 10	10 8	Light	Light	Dark
Fife,	4 men	5 9	11 13	3 light, 1 dark	All light	3 light, 1 dark
Lanark,	1 man	5 5	10 0	Light	Light	Dark
Do.	2 women	5 1	10 9	Light	1 light, 1 dark	1 light, 1 dark
(Skye,	8 men	5 7	10 11	6 light, 2 dark	5 light, 3 dark	3 light, 5 dark
Do.,)	5 women	5 1	9 6	4 light, 1 dark	3 light, 2 dark	1 light, 4 dark
Berwick,	1 man	5 3½	8 7	Light	Light	Light
Forfar,	2 men	5 7	10 0	Light	Light	1 light, 1 dark
Aberdeen,	3 men	5 8	12 5	1 light, 2 dark	2 light, 1 dark	1 light, 2 dark
Mid-Lothian,	7 men	5 8	11 5	6 light, 1 dark	3 light, 4 dark	2 light, 5 dark
Ross,	4 women	5 5	9 9	Light	Light	Dark

IRELAND.

Counties.	Number.	Height.	Weight.	Colour of Eyes.	Colour of Hair.	Complexion.
		Ft. In.	St. lb.			
Leitrim,	31 men	5 6	10 5	29 light, 2 dark	20 light, 11 dark	9 light, 22 dark
Roscommon	17 men	5 7	10 9	All light	13 light, 4 dark	13 dark, 4 light
Sligo,	3 men	5 5	10 2	All light	2 light, 1 dark	2 light, 1 dark
Monaghan,	6 men	5 7	10 12	All light	All light	All light
Armagh,	3 men	5 5	10 6	All light	2 light, 1 dark	2 light, 1 dark
Tyrone,	13 men	5 5	10 5	11 light, 2 dark	8 light, 5 dark	4 light, 9 dark
Down,	6 men	5 7	10 9	All light	4 light, 2 dark	2 light, 4 dark
Longford,	5 men	5 6	9 12	All light	4 light, 1 dark	3 light, 2 dark

MORAL AND STATISTICAL CHART OF THE GLOBE.

INTRODUCTION.

The preceding sheets of this division show the distribution of Man according to races; and it is here proposed to extend the comparative view so as to include the great distinctive characteristics of the Religious Condition, Political Standing, and Civilization of the human family as it exists at the middle of the nineteenth century. A belief in the existence of a Supreme Being is necessary to human progress, and hence the religious sentiment manifests itself as soon as men have formed themselves into societies, imparting to the several constitutions of States their peculiar characteristics, their moral status, and their political privileges. The different modes in which men manifest this sentiment constitute so many different kinds of religions, the external act resulting from which is called worship. These may be classified in the following order:—I. Divine worship, or that of an eternal, unchangeable, omniscient, omnipotent, omnipresent, holy, benevolent Being, as practised by Jews, Christians, and Mohammedans. II. Idol worship, as that of the Hindoos. III. Human worship, as of the Dalai Lama, by the inhabitants of Tibet. IV. Animal worship, as by the ancient Egyptians. V. Devil worship, as by the Yazides and people in the south of India. VI. Fire worship, as by the Parsis. VII. Worship of imaginary beings, commonly malignant, as by many tribes in Africa. VIII. No worship—Atheists, as the Kaffirs, Bechuanas, and other tribes in South Africa.

The body of the Chart shows the distribution of Man according to religion, as explained by the colours. Thus, in the Old World, Christianity is chiefly confined to Europe:—Roman Catholics in the south-west, adherents of the Greek Church in the east, and Protestants in the middle and north. Islamism or Mohammedanism extends from the Atlantic Ocean along the north of Africa, and from Turkey in Europe through the south of Asia to India; while Brahmanism, Buddhism, and various forms of idolatry and superstition, occupy nearly all the remaining regions. In the New World, the portion of North America corresponding to Europe in geographical position, including the United States and the British Provinces, is Protestant; Mexico, and a great part of South America, is nominally Popish; while the vast regions of the north and north-west of North America, and the central and extreme south of South America, are as yet in a state of heathenism.

Judaism has no fixed locality—its followers, as stated in the Tables and Notes, being, with few exceptions, scattered over every region of the globe. The essential characteristic of Christianity is that of progress: it is now spreading in various parts of Asia, Africa, and America, and in some of the islands of the Pacific Ocean. Mohammedanism continues to be, as it has long been, the national creed of the Arabs, Turks, Persians, and other eastern peoples. Brahmanism still holds its sway over the great mass of the population of Hindostan; and Paganism, in its most revolting forms, prevails in the countries of Africa.

The enlarged Map of Europe in the south-east corner of the Chart is intended to show more clearly the intermixture of different religions in the central, eastern, and south-eastern States.[1] The corresponding Map in the south-west corner shows the distribution of languages in Europe, and explains the remarkable fact, that "wherever a language derived from that of Ancient Rome is spoken, the religion of Modern Rome to this day prevails."[2] The enlarged Maps of India, South Africa, and Canada, show the positions of the principal Protestant Mission Stations. The Diagrams at the foot of the Plate indicate the comparative extent of country over which Christianity and idolatry prevail in the world, the comparative numbers of the different religions in Europe, and the estimated progress of education in different States, as deduced from the Notes. In the following statistical Tables, where the elements are very uncertain, the numbers are either omitted, or they are followed by a mark of interrogation. The Notes on the state of religion and education in the margins are intended to explain or supplement the information given in the Tables.

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[1] A comparison of this with the Ethnographic Map of Europe will show that, in general, the Roman Catholic religion corresponds with the Celtic population, the Greek with the Slavonian, and the Protestant with the Teutonic or German.

[2] See Classification of the People of Europe according to Language, page 114, and Notes on Languages in Ethnographic Map of Europe.

AMERICA.

AREA, 3,300 SQUARE DEGREES, OR 15,840,000 SQUARE MILES. POPULATION, 57,359,681. (?)

		POLITICAL RELATIONS.					RELIGIOUS DISTINCTIONS.	
		STATE.	TITLE.	SQUARE MILES.	POPULATION.	DATE OF ESTIMATE.	PROTESTANT.	ROMAN CATHOLIC.
NORTH AMERICA.		RUSSIAN TERRITORY,		394,000	66,000	1852		
		GREENLAND and ICELAND, (DANISH) A		380,000	69,400	1850	See	Note A.
	British North America. Formerly French.	CANADA EAST, (or LOWER) B	Colonies,	209,990	890,261	1851	See	Note B.
		" WEST, (or UPPER)		32,492	952,004	1851		
		NEW BRUNSWICK,		27,700	193,800	1851		
		NOVA SCOTIA and C. BRETON,		18,746	276,177	1851		
		PRINCE EDWARD ISLAND,		2,134	62,678	1848	26,554	20,430
		NEWFOUNDLAND,		36,000	95,506	1845	49,490	46,785
		HUDSON BAY TERRITORY,		3,000,000	100,000 ?	1852		
		LABRADOR,		170,000	5,000	1851		
		HONDURAS,		62,740	11,066	1848		
	Formerly English, French, Spanish.	UNITED STATES of AMERICA, C	Republic,	3,260,000	23,263,488	1850	Note C.	1,500,000 ?
	Formerly Spanish.	UNITED STATES of MEXICO, D	Republics,	1,100,000	7,200,000	1852	Note	D.
		CENTRAL AMERICA,		263,740	2,162,000 ?	1852	100,000 ?	2,000,000 ?
	West India Islands.	INDEPENDENT—						
		S. Domingo, HAYTI, E	Empire,	11,000	700,000	1852	See	Note E.
		S. Domingo, DOMINICA,	Republic,	18,000	200,000	...		
		BRITISH,	Colonies,	13,414	820,792	1852		
		FRENCH,		343	129,050	1841		
		SPANISH,		46,248	1,020,802	1849		
		DUTCH,		600	26,302	...		
		DANISH,		131	39,614	...		
		SWEDISH,		25	9,000	...		
SOUTH AMERICA.	Guiana.	BRITISH, F		76,000	126,000	1851	See	Note F.
		DUTCH,		38,500	64,270	1852	10,000	6,000
		FRENCH,		21,500	22,010	1841		
	Formerly Spanish.	NEW GRANADA, G	Republic,	380,000	2,000,000	1850	See	Note G-p.
		VENEZUELA, h	...	774,000	1,250,000	1852		
		ECUADOR, i	...	325,000	600,000 ?	...		
		PERU, j	...	523,500	1,500,000 ?	...		
		BOLIVIA, k	...	316,000	1,000,000 ?	...		
		CHILE, l	...	143,500	1,090,000	1843		
		ARGENTINE REPUBLIC, m	...	800,000	2,000,000 ?	...		
		URUGUAY, n	...	120,000	200,000 ?	...		
		PARAGUAY and ENTRE-RIOS, o	...	150,000	300,000 ?	...		
	Formerly Portuguese.	BRAZIL, p	Empire,	3,000,000 ?	7,500,000 ?	...		5,000,000 ?
		PATAGONIA, &c.,		330,000 ?	840,000 ?	...		

REMARKS.

A Danish America comprises Greenland and Iceland—the former having, in 1850, a population estimated at 9,400, of whom about 200 were Europeans. The natives, who are docile and harmless, are congregated in groups at different fishing stations. They have no fixed form of superstition or idolatry, but are grossly ignorant. The Danish missionaries and the Moravian brethren have laboured among them, the former for 132 and the latter for 120 years; and on the west coast, as far as their mission extends, (lat. 72° N.,) nearly all the natives profess Christianity. The inhabitants of the east coast are still heathens; but their number is small, and they are nearly inaccessible.

The population of Iceland, in 1850, was 60,000. The Icelanders belong to the Norwegian race, and speak the ancient Scandinavian language, or the Danish. They are Lutherans; and although there are few schools, elementary instruction is maintained by domestic teaching. There is a Latin school near Reikiavik, and a printing establishment in the island of Vadoe.

B British America.

CANADA.

The population of Canada, according to the census of 1851, is comprised of—

Origins.	E. Canada.	W. Canada.
English,	11,230	82,699
Irish,	51,499	176,267
Scotch,	14,565	75,811
Canadian French,	669,528	26,417
" not French,	125,590	526,093
From Continental Europe,	624	11,473
From United States,	12,482	43,732
Other places,	4,733	9,512

At the same date the population, according to religion, was—

	E. Canada.	W. Canada.
Church of England,	45,402	223,190
Church of Scotland,	4,047	57,542
Church of Rome,	746,866	167,695
Free Presbyterians,	267	65,807
Other Presbyterians,	29,221	80,799
Wesleyan Methodists,	5,799	96,640
Episcopal Methodists,	7	43,884
New Connection,	3,442	7,547
Other Methodists,	11,935	59,585
Congregationalists,	3,927	7,747
Baptists,	4,493	45,353
Lutherans,	18	12,089
Quakers,	163	7,460
Jews,	348	103
Others not classed,	22,556	34,854
	890,261	952,004

The most energetic and praiseworthy exertions are being made in Canada, especially the western province, for the education of the people. A new School Act came into operation in 1847;[1] and in 1852 there were, in West Canada, 8 colleges, with 721 students; 1 normal and 1 model school, with 245 students; 98 grammar schools, with 3,194 students; 3,010 common schools, with 170,587 pupils; 167 private schools, with 5,133 pupils—making a total of 3,285 educational establishments in operation, with 188,910 students and pupils. The entire population between the ages of 5 and 16 was, at the same date, 262,755. In East Canada the number of schools, in 1851, was 2,005. The number of children attending school was, at the same date, 79,248; adding to which the number of pupils attending the colleges and other educational institutes, estimated at 10,000, the total number of pupils would amount to 90,000.

The press is advancing rapidly in Canada; the journals are unstamped, and there is no duty on paper or advertisements; there are 20 newspapers in East, and 30 in West Canada. Some of these are daily papers, and several of those in East Canada are entirely in the French language.

NEW BRUNSWICK.

In 1849, the number of churches or chapels belonging to the different denominations was estimated as follows:—Church of England, 61; Church of Rome, 60; Church of Scotland, 27; Wesleyan Methodist, 57; Baptist, 65. The Roman Catholic diocese includes Prince Edward Island: the Roman Catholics are principally Irish and Acadians.

There is a university at Fredericton, and the education of the people is carefully and judiciously promoted. There are 11 grammar schools, with 466 pupils; and 571 parish schools, with 17,903 scholars.

NOVA SCOTIA.

The population is composed of French, English, Irish, Scotch, and Anglo-Americans. The French, or Acadians, are located mostly in Cape Breton, the Irish in the capital, the Scotch in the eastern districts, and the Anglo-Americans in the north and midland counties.

In 1851 the number of churches in the province was 567, with members as follows: Church of England, 36,482; Roman Catholics, 69,634; Presbyterians — Kirk of Scotland, 18,867; Presbytery of Nova Scotia, 28,767; Free Church of Scotland, 25,280; Baptists, 42,243; Methodists, 23,596; Congregationalists, 2,639; Universalists, 580; Lutherans, 4,087; Sandemanians, 101; Quakers, 188; other denominations, 3,791.

Education is actively promoted by the legislature, as well as by many private individuals. There is at Halifax, a National, a Catholic, Acadian, Grammar, and St George's schools; and academies at Pictou, Windsor, Horton, Yarmouth, Annapolis, &c. Besides these, in the several districts of the province, there were, in 1847, 1,025 common schools, with 34,380 scholars. The schools are supported partly by the province, and partly by subscription; poor children are educated gratuitously. The press is entirely free. There are 13 newspapers in the capital, and 5 in the interior. The circulation of English newspapers has increased a hundredfold since the establishment of the line of steam packets.[1]

In 1839, Newfoundland, which previously formed part of the diocese of Nova Scotia, was, with the Bermudas, formed into a separate see. The Protestant population comprises—Church of England, 34,281; Wesleyans, 14,239; Presbyterians of the Church of Scotland, 576; Congregationalists, 394. The Roman Catholics (46,785) have 42 churches, and a cathedral at St John's. Education is provided for by an act of the local government, under which elementary schools are established in every district of the island, besides 6 grammar schools and academies, and a male orphan asylum, with 470 children. The act empowers the Governor to constitute, in each district, two separate boards of education, (Protestant and Roman Catholic,) by nominating seven respectable inhabitants of each creed to each section—one resident clergyman of each persuasion being, *ex officio*, a member of his respective board. This scheme has been found both efficient and satisfactory. The amount expended for this object in 1847 was £6,067. The Newfoundland and British North American School Society has established 40 schools, on the Madras system, with (in 1848) 2,784 pupils.

More than half the population of Prince Edward Island is composed of Scotchmen; there are about 5,000 Acadian French, and only 30 or 40 families of aborigines—the Mic-Mac Indians. The proportions of religions is stated according to the census of 1841, when there were, belonging to the Church of England, 5,707; Presbyterians of the Church of Scotland, 10,006; Presbyterians of the Island, 5,039; Roman Catholics, 20,430; Methodists, 3,421; Baptists, 1,609; other denominations, 772. Education is provided for by a central academy at Charlotte-town, with 90 male pupils; a national school, with 30 male and 10 female pupils; and 110 primary schools in the different districts. On these the local government expends about £1,000 per annum. Three school inspectors report to the legislature annually. There are infant schools in Charlotte-town, George-town, and St Eleanors.

The territories of the Hudson Bay Company comprise nearly all the north-west of North America, except the Russian territory; the area is estimated at more than three millions of square miles; and the Indian population, between lat. 42° and 54° N., at 86,947. At the 136 forts of the Company there are 25 chief factors, 27 chief traders, 152 clerks, and 1,200 regular servants. Ministers of the Gospel, of every denomination, are protected and encouraged. There is a bishop of the Church of England, and stations of the Church Missionary Society at Red River Settlement and several other places.

C United States.

The population of the United States—which in 1790 was 3,929,872; in 1820, 9,638,131; in 1840, 17,063,353—had, in 1850, increased to 23,263,488. Between 1840 and 1850 new territory was added to the extent of 1,166,432 square miles. So many conjectures have of late been hazarded regarding the origin of the present population of the United States, that it may be desirable, before stating results, shortly to trace the progress of colonisation. The first English colony was founded in Virginia, by Sir W. Raleigh, in 1584, but the first permanent English settlement was that of Jamestown, in 1607. Acadia was colonised by France in 1604. The pilgrim fathers landed at Plymouth, Massachusetts, in 1620. From 1625 to 1632, the English settled at Barbadoes, St Kitts, Nevis, the Bahamas, Antigua, and Montserrat—the state of Massachusetts was settled by them in 1628, New Hampshire in 1629, and Carolina in 1631. In 1663 Maryland was settled by English Roman Catholics, under Lord Baltimore; Connecticut was settled in 1635; in 1637, Maine and New Hampshire were colonised from Connecticut; and North Carolina was settled in 1650. In 1663, Canada was made a Royal British Colony, and in 1664, New Netherlands (now New York, New Jersey, and Delaware,) was conquered by the English from the Dutch, and the name of its capital, Manhattan, changed to New York. Pennsylvania was planted by William Penn, and Philadelphia founded, in 1682. In 1711, Newfoundland was colonised by England. Acadia and Hudson Bay territory were ceded by France to England at the peace of Utrecht, in 1713. Georgia was colonised by the English in 1732; and Savannah founded 1733. Louisburg and Cape Breton were taken from France by the English in 1745. Acadia (now Nova Scotia) was settled by the English in 1748, and Cape Breton in 1758.

The Dutch had a considerable influence in early times, but the purely Dutch element is now so small that it can hardly be traced beyond Massachusetts, where it is strongest, and parts of New York, New Jersey, and Pennsylvania. Delaware was settled by the Swedes and Finns. The Germans occupied the interior of Pennsylvania in the eighteenth century, when they became so numerous as to perpetuate their language, a corrupt form of which still predominates in some districts. During the present century, Germans have swelled the population of all the principal cities, but they have not stamped their peculiarities on any state of the Union; they are most numerous in Virginia and Texas. The French Huguenots emigrated in considerable numbers during the reign of Louis XIV., and many of their countrymen joined them at the French Revolution. There were several thousands of French descent in Louisiana, at the time of its acquisition. There are Spaniards and their descendents in Florida, Louisiana, Texas, New Mexico, and California; and scattered over the vast territory are, Portuguese from Madeira, Italians, Poles, Hungarians, Indians, and Africans. Irish emigrants have settled in America since the beginning of the eighteenth century, but their number has been small till within a few years—the great mass having emigrated or been born since 1820. It thus appears that the whole extent of country, from Canada to Florida, was originally peopled mostly by English emigrants and their descendants, and that the foundation of the United States nation was laid by one race of people, the Anglo-Saxon, with but a slight intermixture of foreign blood.

By the seventh census it appears that, of the free inhabitants of the United States in 1850, 17,737,505 were natives of its soil, and 2,210,828 were born in foreign countries. The nativity of 39,014 could not be ascertained. 1,965,518 of the total number of foreign-born inhabitants were residents of the free states, and 245,310 of the slave states. Persons of foreign birth, therefore, form 11 per cent (11.06) of the whole free population. The countries whence are derived the greater portions of the living immigrant population are:—

	Total.	Per cent.
Ireland,	961,719	43.04
Germany,	573,225	25.69
England,	278,675	12.06
British America,	147,700	6.61
Scotland,	70,550	3.17
France,	54,069	2.44
Wales,	29,868	1.34
Miscellaneous,	95,022	4.47

Negro slaves were first introduced from Africa by a Dutch ship, in 1620. The slave-trade was afterwards carried on by English ships exclusively, for 150 years. On the declaration of independence, in 1776, there were about 500,000 negro slaves in the country, distributed over all the colonies, but chiefly in the southern states. The slave population was, in 1800, 893,041; in 1820, 1,538,064; in 1840, 2,487,355; and in 1850, 3,204,067. Of these there were, in the 15 slave-holding states, 3,200,380—the remainder being distributed throughout the districts and territories. The free population of these 15 states amounted, at the same date, to 6,412,151; the proportion of free to slaves being nearly as 2 to 1. There are 400,000 free people of African origin in the United States, who are the descendants of slaves, if they were not slaves themselves. In the year ending June 1, 1850, 1011 slaves escaped from their owners, 1467 were manumitted, and 562 coloured emigrants were sent to Liberia by the Colonisation Society.

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[1] See Reports of the Rev. Dr Ryerson, chief superintendent of schools in Upper Canada.

[1] Martin's *British Colonies*.

The prevailing creeds of the people of the United States of North America are no less diversified than the races, as shown by the following enumeration from the census of 1851:—

	Number of Churches.	Total number of Seats.
Baptist,	8,791	3,130,878
Christian,	812	296,050
Congregational,	1,674	795,117
Dutch Reformed,	324	181,986
Episcopal,	1,422	625,213
Free,	361	108,605
Friends,	714	282,823
German Reformed,	327	156,932
Jewish,	31	16,576
Lutheran,	1,203	531,100
Mennonite,	110	29,900
Methodist,	12,467	4,209,333
Moravian,	331	112,188
Presbyterian,	4,584	2,040,316
Roman Catholic,	1,112	620,950
Swedenborgian,	15	5,070
Tunker,	52	35,075
Union,	619	213,552
Unitarian,	243	137,367
Universalist,	494	205,462
Minor sects,	325	115,347
Total,	36,011	13,849,896

Besides these 36,011 churches in the different states, there are 210 in the district of Columbia and the Territories. There is thus 1 church for every 557 *free* inhabitants, or 1 for every 646 of the entire population.

The original Roman Catholic population of North America was very small, and chiefly confined to Maryland. It received considerable accessions on the acquisition of Louisiana by the United States Government in 1803, and a few thousands by the purchase of Florida in 1819; but the great source of its increase has been immigration from Ireland, Germany, and France. In 1850 there were 4 archbishops, 30 bishops, 1073 churches, and 1081 priests. The number of adherents is probably about 1,500,000;[1] they have 1112 churches, 13 colleges, and numerous schools.

Besides these different Churches, the United States contain numerous strange sects, among which the most noted are the Mormons and the Shakers. The Mormons, or Latter-Day-Saints, originated with Joseph Smith, their first prophet, in 1830. They established themselves first at New York, then in Missouri, whence they were driven to Ohio; but being expelled thence, they returned to Missouri, and built the town of Far-West. Driven again from Missouri by the military, they sought an asylum in Illinois, where, in 1840, they settled at Nauvoo. Persecution again drove them away, and they retired beyond the Rocky Mountains, and founded the state of Utah. The principal part of the Mormon dogma consists in the belief of a revelation specially for America. They permit polygamy, and are accused of many other immoral doctrines.

The *Shakers* are the counterpart of the Mormons, since they do not recognise marriage, and consider celibacy as the perfect state. Their chief establishment is at *Watervliet*, in the state of New York; but the first established and largest society is at New Lebanon, in the same state. The sect was founded by Ann Lee, daughter of John Lee, a native of Manchester, in 1776. Their chief dogma consists in recognising the necessity of a revelation by a feminine Saviour, and the incarnation of Christ in the two sexes successively.

If the intellectual civilisation of a country is to be judged of by its literature, its arts, and the eminence of its authors and artists, then the United States would rank among the least of intellectually civilised nations; but if this be judged of according to the average instruction of the mass, then there are few nations more civilised, for there are few nations in which the means of education are so freely awarded to all. But superior instruction, the cultivation of the taste and the intellect, is not so widespread. Literature is in its infancy, and great authors are rare. Education is eminently practical, and has nothing speculative in its nature. Primary instruction is gratuitous, but not obligatory. Primary schools are supported at the expense of the districts, and no necessary expense is grudged—more money being sometimes raised than the law requires,[1] which limits the minimum amount of the tax, but not the maximum. The schools are well furnished, and the teachers liberally remunerated.

The best educated states are those of *New England*, where the proportion of the population attending school is equal to that of the best instructed countries of Europe. Among these Massachusetts is pre-eminent; there the public schools are free to all, the teachers being supported by a tax on each township; and the state is celebrated for its literary and scientific institutions.

In Connecticut primary education is universal, and the system of common schools excellent. In Maine, Vermont, and Rhode Island, the means of education are ample, but the system of tuition is not equal to that of Massachusetts. New Hampshire makes liberal provision for education: here Roman Catholics, few in number, are excluded by the constitution from political power—this being the only state in the Union in which a preference is given to one religious sect over another.

Among the *Middle States*, New York holds the first rank in respect to education. By the census of 1850, it is shown that the whole number of children in the state, between the ages of 5 and 16, were under instruction, for periods varying from 4 to 10 months in the year. In New Jersey all the children, between the ages of 5 and 16, were under instruction for a period averaging 9 months in the year. In Pennsylvania education is general and well conducted, but not equal to that of New York. A large majority of the population of Maryland is Roman Catholic; primary education is free, but by no means general: the higher schools are, however, good.

In Delaware education is miserably conducted. In 1850, 19,523 persons, nearly the fourth of the entire population, of the age of 20 and upwards, were unable to read or write. But means are being adopted to remedy this evil.

In the *Southern States*, Virginia is respectably provided with schools; North Carolina has made considerable progress of late, but still the educational destitution is lamentable; in South Carolina and Georgia it is very deficient. Florida is far behind in education; for although the state provides schools, the population is so sparse as to prevent their being taken advantage of.

Among the *Western States*, Ohio ranks first in education; here the primary schools are scarcely inferior to those of Massachusetts and New York. Indiana, Illinois, Michigan, and Wisconsin, have each made fair provision for primary instruction. In Kentucky the common schools are very defective. Mississippi has a university at Oxford, but common schools are very deficient; in 1850, the number of adults unable to read was 8360. Iowa has ample funds for schools to be established.

In the *South-Western States*, Tennessee has few schools as yet, but ample funds are provided for education. Alabama has several celebrated academies, and good common schools. Arkansas has no collegiate institution, and few primary schools. Louisiana has a university at New Orleans, but primary education is very defective.

The superintendent of the late census says—"There appears to be no inhabited space without its schools and churches, for promoting the education and morals of our people. Institutions are everywhere rising to protect comfortably those visited with the infirmities of life, for the restoration of lost or impaired reason, and for the instruction of those whose education was formerly held to be impossible and hopeless." . . . . "Near 4,000,000 of our youth were receiving instruction in the various educational institutions of the country on the 1st June 1850, or at the rate of 1 in every 5 free persons. The teachers number more than 115,000, and the colleges and schools near 100,000."

The religious societies of the United States, in 1850, comprised 3 Bible Societies, 1 Tract Society, 9 Home Mission Societies, 4 Sunday School, 3 Educational, and 14 Missionary Societies.

The American press is the most prolific in the world. Every village has its journal,[2] the necessity of reading which is one of the natural wants of the American. The number of journals in the Union—exclusive of those published in the new states, Oregon, Texas, Minesota, and California—was, in 1850, 5000, and the number of copies issued annually, upwards of one million.

D Mexico.

The only public recognised religion of Mexico is the Roman Catholic, but some others are tolerated. In 1850, the number of monks, chiefly Franciscan, was reckoned at 1,998; there were, at the same date, 156 convents. The Spanish monks were expelled during the late revolution, and their places have been filled by Creoles, whose morals are not creditable. Religion has but little influence on the white population; and the hold of the Church on the Indians, never complete, is now fast giving way. Education, intrusted to the care of an ignorant priesthood, is nearly unknown among the common people; there is, however, a Lancasterian association for primary instruction. The university of Mexico enjoys a considerable reputation, and there is a school of medicine, and a school of mines.

Central America.

The central portion of America was a Spanish colony, under the name of Guatemala, from 1502 to 1821, when, after three years of anarchy, it was formed into the confederation of Central America, which lasted from 1824 to 1839. It is now divided into the independent republics of Nicaragua, Honduras, Guatemala, and Costa Rica. The population comprises Indians, estimated at 700,000; whites, 500,000; ladinos, 700,000, and a few blacks and mulattoes. There are no negroes in Costa Rica.

The Roman Catholic religion is the only one recognised by the different states, but all others are tolerated, in some measure. Monachism and personal slavery are entirely abolished, and the few nunneries which remain are open and voluntary. Education is yet in its infancy; but arrangements have been made for the gratuitous instruction of the population in all the states; and in that of Costa Rica, 79 primary schools have been instituted. These are distributed through all the districts, even the poorest and most remote. The state has, besides, a university, with 12 professors, and, in 1850, 150 students.

E West Indies.

Hayti, or San Domingo, is the only independent island of the Antilles. It was held by Spain till 1665; the French then obtained a portion, and held it till 1790, when a revolution broke out, and it was declared independent in 1800. The Spanish portion of the island, Dominica, is now a republic; and the former French portion, Hayti, an empire, under the negro prince, Faustin I. French is the most general language of the island, but Spanish is spoken in the east. The Roman Catholic is the state religion, but all others are tolerated. Public instruction is but little cared for, and of the many educational establishments founded by the Spaniards, the university of San Domingo is almost the only one that remains.

The British West Indies comprise the following islands:—

	Date of Estimate.	Square Miles.	Population.
Antigua,	1849	168	36,190
Barbadoes,	1851	166	135,939
Dominica,	1848	291	22,200
Grenada, &c.,	1851	155	32,671
Jamaica,	1848	5,468	379,690
Montserrat,	1851	49	7,000
Nevis and Redonda,	1851	30	10,280
Virgin Isles,	1841		6,689
St Christopher, and Anguilla,	1848	97	23,177
St Lucia,	1851	225	24,185
St Vincent,	1851	131	30,128
Tobago,	1844	187	13,027
Tortola,	1844		6,689
Barbuda,	1851	86	629
Trinidad,	1851	2,000	68,600
Bahamas,	1851	4,000	27,519
Turks Islands,	1851	400	3,490
Bermudas,	1851	47	11,092

The emancipation of the negro race from slavery, and the putting them in possession of all the privileges enjoyed under the British constitution in the nineteenth century, was attended in the first instance with very beneficial results as regarded the negroes themselves. But, in consequence of a combination of unfavourable circumstances, the island of Jamaica has of late years suffered exceedingly;—a great number of estates have gone out of cultivation, and a large portion of the negro population is now in a very depressed condition.

The French possessions in the West Indies comprise the islands of Martinique, with a population of 121,478, of whom 9000 are whites or creoles, holding the greater part of the capital and trade of the island; 37,000 coloured people, who were nearly all free previous to 1848, and who are employed as merchants, fishermen, or cultivators of sugar and coffee; and 75,000 negroes, emancipated in 1848;—Guadaloupe, with its dependencies—Marie-galante, Saintes, Désirade, and part of St Martin—with a population of 130,780, of whom about 11,000 are white, and 15,000 coloured; the rest being negroes emancipated previous to or during 1848.

Of all the vast territories formerly comprised in Spanish America, there now remains to Spain only the islands of Cuba, Porto Rico, and part of the Virgin Isles, with a population of 1,020,862. Cuba had, in 1847, 938,752 inhabitants.

The Dutch West Indies comprise the islands of St Eustatius, Curaçao, Bonaire, Saba, and part of St Martin, with a population of 6,560 Protestants, 17,320 Roman Catholics, 765 Jews, and 1657 Pagans.

Denmark possesses the islands of Santa Cruz, St. Thomas, and St Jan.

Sweden has only the island of St Bartholomew, with 9000 inhabitants.

F British Guiana, comprising Demerara, Essequibo, and Berbice, has a population of 126,000.

Dutch Guiana had, in 1852, a population comprising 10,000 Protestants, half of whom were Moravian Brethren, chiefly negro slaves under the instruction of Moravian missionaries, 6000 Roman Catholics, 1500 Jews, and 47,000 Pagans.

The population of French Guiana comprises 3000 whites, 5000 coloured, and 14,000 free negroes, a large portion of whom are concentrated in the isle of Cayenne.

G–p South America.

The northernmost portion of South America, named by the Spaniards Terra Firma, formed, during the war of independence, the republic of Columbia, which lasted till the death of Bolivar, 1830. It is now divided into the three separate and independent republics of New Granada, Venezuela, and Ecuador.

The population of New Granada is composed of whites (Spanish Americans), Indians, and negroes, or men of colour. There are now few slaves in the republic. By a law of July 21, 1821, the children born from that date were to be free, only they were to remain till the age of 18 with the masters of their parents, who were bound, for their service, to support and educate them. At the same time means, which are still in operation, were adopted for the gradual manumission of slaves, so that in 1850 there were not more than 10,000 in the entire republic. A treaty with Great Britain for the suppression of the slave trade was signed at Bogotà in 1851. The Roman Catholic is the religion of the state, but complete religious toleration is guaranteed by a law of 1849; at the same date, monastic institutions were deprived of their privileges. The government has made great efforts to educate the people, by the introduction of a school in each district, on the Lancasterian system. In 1850, the provincial colleges were remodelled, and 3 new female schools, a military, and a nautical school, were established. In 1850 it was estimated that 1 in 80 of the population were receiving primary instruction in the schools.

h In 1834, the population of Venezuela was estimated by an official statement to comprise 200,000 whites (Spanish Americans), 207,000 Indians, 433,000 free coloured, and 60,000 slaves. As in New Granada, slavery is being gradually extinguished; the children of slaves are born free, with a condition of service till the age of 18. The existing slaves are manumitted on payment of an easy indemnity. No existing slave can be sold out of the territory, and no foreign slave can be admitted. The religion of the republic is Roman Catholic: the clergy possess great power. Other forms of religion are tolerated, but public rites and worship are denied. Many of the Indian tribes have nominally embraced Popery. There is a university at Caracas for ancient and modern languages, theology, law, and medicine; and the state has 13 other colleges, but there is no general education. From approximate calculations, it appears that not more than 1 in 114 of the population receive primary instruction.

i Ecuador has a population and laws similar to those of New Granada and Venezuela. The number of existing slaves was, in 1850, estimated at 2000. The religion of the state is Roman Catholic; there are about 50 convents and nunneries. Public instruction is provided for by the state. There is a university at Quito, a naval school at Guayaquil, 9 colleges, and 272 primary and secondary schools throughout the republic, having, in 1850, about 10,000 scholars, or 1 in 60 of the population.

j The population of Peru comprises whites, Indians, negroes, and a mixed race. Notwithstanding the equality professed by its democratic institutions, there is continual warfare between the conquering and the conquered races. The Spaniard of the coast despises the Indian; and the inhabitant of the mountains, the *Serano*, hates the citizen.

The Roman Catholic is the only form of religion recognised or tolerated by the state, and the Church is very wealthy. Lima has a university and several other colleges. Schools for reading, on the Lancasterian plan, are established in the capital and the larger provincial towns; but the Indians and negroes are in a state of gross ignorance.

k The great majority of the population of Bolivia are indigenous Indians; the free negroes or mulattoes met with, are generally fugitives from Brazil.

The religion of the state is Roman Catholic. In 1845, public instruction was reformed and re-organised on the European model; a university was founded, colleges and primary schools opened, and a complete plan of instruction promulgated; but for want of professors, teachers, and money, the whole has been suspended.

l In Chile the population is chiefly of Spanish and Indian descent, but there are some negroes and mulattoes. The religion of the state is Roman Catholic; but, on account of the great number of foreigners located in the country, there is a certain toleration of other forms of religion, and there is a Protestant Church at Valparaiso. There are 31 convents and 7 nunneries in the state. A university was established at Santiago in 1842. Since 1843, secondary instruction has been managed by a national institute. There is an English and a French college at Valparaiso; and 150 primary schools are maintained at the expense of the state. A comprehensive law for the regulation of public instruction was recently presented to the national congress, but political events have prevented its operation.

m The Argentine Republic consists of the provinces of Buenos Ayres, Entre-Rios, Corrientes, Santa Fé, San Luis-della Punta, Cordova, and Santiago del Estero. The population comprises about 1,200,000 Creoles, Spaniards, or Metis; 200,000 subjugated Indians; and 25,000 negroes. The Roman Catholic is the religion of the state; but all others are tolerated by a law of 1825. Although convents were abolished some time since, there are still 2 at Buenos Ayres, where there is also an Episcopalian and a Presbyterian church. Public instruction is managed by a superior commission, under the president. The university has been suppressed. There are 2 colleges for secondary instruction; but primary instruction, little advanced in the towns, is unknown in the rural districts.

n The State of Uruguay, or Banda Oriental, has long been the theatre of a desolating war, first from the rivalry of Spain and Portugal, and next of Brazil and the Argentine Republic. In 1830 its population amounted to only 70,000; but, by liberal conditions offered to immigrants, it has been more than doubled in twenty years.

o In Paraguay the great majority of the population is Indian. There are a few native Spaniards, negroes, and mixed races. The government holds 1000 slaves, formerly the property of the Jesuits. The religion of the state is Roman Catholic. So-called primary schools are plentiful, and education is general to the extent of being able to read; but as there are no books, and the printing-press does not exist, it is of no practical value.

p Brazil remains a constitutional monarchy in the midst of the republics of Spanish America. Its population, amounting to about 5,000,000, exclusive of the still savage Indians and slaves, comprises Brazilians, those born of Portuguese parents in Brazil; Creoles, those born of African mothers; mamlucos, the offspring of whites and Indians; cariboccos, born of negroes and Indians; and cabros, born of mulattoes and negroes. The indigenous tribes are called by the Portuguese, Anthropophagi. The religion of the empire is Roman Catholic. Convents and nunneries are not suppressed, but they are few in number. The state professes to provide gratuitous instruction to all its population; every parish is reported to have a school for boys and another for girls, and every town or large village a Latin school; five of the larger cities have each a Greek school—all gratuitous. Rio Janeiro and Bahia has each a school of medicine; and the state has besides, military and marine schools, and colleges of law and philosophy. To all the schools every one is admitted, without distinction of colour, nationality, or religion; and slaves are admitted to the primary schools, with the permission of their masters. In 1849 the public schools were said to be attended by 43,215 pupils. The literature of Brazil has little originality; it is mostly confined to translations. The press is quite free.

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[1] On this subject it is exceedingly difficult to arrive at an accurate estimate. Archbishop Hughes of New York calculates their number in 1850 at 3,000,000; while the authors of the *Catholic Almanac*, published at Baltimore, for the same year, make it 1,650,000; the *American Almanac* for 1853, 1,233,350; and the *Annuaire des Deux Mondes*, 1852, p. 777, 1,980,000. From the census tables above, it appears that the aggregate accommodation or total seat-room in all the Roman Catholic churches is only 620,950.

[1] Dr Baird in the *Religious Condition of Christendom*.

[2] Professor Johnston mentions the small town of Farmington, in Connecticut, which, for a population of 2,000, receives 130 different agricultural journals.

THE Aborigines occupied the whole of North America at the period when the first colonies were planted. Great efforts have been made by missionary bodies for their civilisation since 1817. The government for some years appeared disposed to pursue a just and benevolent policy towards them, but a party being desirous to obtain possession of their lands, though they had been secured to them both by treaties and the law, procured an Act of Congress in May 1830, setting apart a territory west of the Mississippi and Missouri for such tribes as might choose to give up their lands, and remove thither. To this transfer many of them were exceedingly averse, and long resisted all the efforts of the government; but, after a lengthened struggle, they were forced to yield. The territory acquired from the Indians since the establishment of the present Federal Government amounts to 481,644,443 acres, for which compensation in money and goods was paid to the amount of 35,274,877 dollars. The number of acres given in exchange, or reserved, is 62,728,927, the value of which, at 1¼ dollars per acre, is 71,041,723 dollars. Some of the tribes had advanced considerably in Christianity and civilisation previous to their removal, which event proved a great hindrance to their progress. They had a regular government, and were rapidly acquiring habits of industry. An alphabet of the Cherokee language was invented by a native, and a newspaper—Cherokee and English—was edited by a Cherokee, and printed at a press belonging to the tribe. They are now recovering from the effects of their retrogression. School books and part of the Bible have been printed in the languages of the Cherokees and Choctaws; and education is advancing among some of the tribes, although others are still sunk in the ignorance of heathenism and barbarism. In 1850, the number of communicants of various tribes connected with the principal missions amounted to 3964. Nothing has proved a greater bane of the Indian race than the "fire waters," as they emphatically call ardent spirits, which the white people continue to sell to them to their ruin. Now that the United States Government has effected its purpose in the removal of the Indians, it appears quite disposed to promote measures for their education and civilisation.—See *American Missionary Herald*, 1852, and *Foreign Missionary Chronicle of the Presbyterian Church in the United States*, vols. vi. and viii.

AUSTRALASIA.

633 SQUARE DEGREES, OR 3,038,400 SQUARE MILES.

POLYNESIA.

245 SQUARE DEGREES, OR 1,170,000 SQUARE MILES.

REMARKS.

	POLITICAL RELATIONS.				RELIGIOUS DISTINCTIONS.			
	STATE.	SQUARE MILES.	POPULATION.	DATE OF ESTIMATE.	PROTESTANT.	ROMAN CATHOLIC.	JEWS.	PAGANS, &C.
AUSTRALIAN COLONIES.	NEW SOUTH WALES, . **A**	?	208,254	1852	127,773	56,899	979	1,592
	VICTORIA, ... **B**	58,342	77,345	1851	18,014	364	625	
	SOUTH AUSTRALIA, . **C**	300,000	67,430	1851		See note C		
	WESTERN AUSTRALIA, **D**	1,000,000	5,904	1850	311	337		479
	TASMANIA, OR VAN DIEMEN'S LAND, . . **E**	25,000	70,164	1850	53,794	8,904	452	29
	NEW ZEALAND, . . **F**	36,000	31,967 !	1849				

REMARKS.

A THE Protestant population of New South Wales comprised, in 1846, Church of England, 93,137; Church of Scotland, 18,156; Wesleyans, 10,008; other sects, 6472. The colony of Australia was erected into an Episcopal see in 1836. Education is progressing, but is still very deficient. By the census of 1846 it appears that there were then, under 21 years of age, 18,563 males and 18,035 females who could not read; 5480 males and 6159 females who could read only; and 9323 males and 9078 females could read and write. Above 21 years, 14,245 males and 7160 females could not read; 7150 males and 6209 females could read only; and 37,623 males and 15,504 females could read and write.

There is a college at Sydney, which in 1846 had 90 students.

Missions have made but little progress among the natives, the adults showing no desire to embrace Christianity.

B Victoria was declared an independent colony in November 1850. In 1851 the population amounted to 77,345, besides about 3000 aborigines. The religious persuasions comprised, Church of England, 37,433; Presbyterians, 11,608; Wesleyans, 4988; other Protestants, &c., 4313; Roman Catholics, 18,014; Jews, 364; Mohammedans, &c., 201; other persuasions, 424.

Education is aided by the legislature, which approved of the national system; but being opposed by the clergy generally, it was not adopted; and grants are now voted for educational establishments as public schools. £50,000 have been voted towards a Melbourne university.

C In 1850 the population amounted to 63,700, besides aborigines, estimated at 3730. The Protestant population comprised—Church of England, 11,945; Church of Scotland, 1958; Wesleyans, 2246; other Dissenters, 2888.

Education is being generally extended. In 1849 there were 81 day schools, attended by 2900 children; and 45 Sunday schools, with 2500 pupils, in the province. There is a grammar school at Adelaide with 200 pupils, and a school for the children of the aborigines, with 58 pupils, in 1849.

D The aborigines of Western Australia have attained a superior position to those of the *other colonies; they are found active, intelligent,* and honest. In 1848, 541 *were receiving regular or casual employment from the colonists.*

The Protestants comprised—Church of England, 3063; Wesleyan Methodists, 276; Independents, 187; other Dissenters, 188.

Public instruction is entirely secular. The government schools are under a board of education. The Irish national system is adopted in the Roman Catholic schools. In 1848 there were 11 government schools and 444 pupils.

E The religious population is exclusive of the troops and convicts at penal stations. The Protestant population comprised—Church of England, 44,490; Church of Scotland, 4552; Wesleyans, 2566; other Dissenters, 2186.

There is a public board of education, and both public and private instruction is well provided for. The chief educational establishments are Christ College, at Bishopsbourne, opened in 1846; and the High School, established at Hobart Town in 1847. The Sunday School Union of Van Diemen's Land has 22 stations, 154 teachers, and 124 pupils.

F The colony of New Zealand consists of the three islands, New Ulster, or North Island; New Munster, or Middle Island; and New Leinster, or South Island. The north island is believed to contain 100,000 aborigines; and the total number in all the islands is estimated at 120,000. In 1850 the Church Missionary Society had 23 mission stations in New Zealand, with 30 European missionaries and teachers, and 461 native teachers. The Wesleyan Missionary Society had 20 missionaries and 3000 native communicants. Under these missionaries were 235 native preachers, and 390 native Sabbath school teachers.

In New Ulster 2520 of the European population could not read in 1848, while 1709 were under daily instruction. The Colonial Secretary estimates that "26 per cent of the children between 5 and 14 are receiving no daily instruction in schools in New Munster, while nearly all the aboriginal inhabitants can read and write."[1]

POLYNESIA.

Under this term are included the islands scattered over the Pacific Ocean, chiefly within 30° on each side of the equator, and from longitude 135 E. to 135 W. The principal groups north of the equator are the Pelew, Ladrone, Caroline, Marshall, Gilbert, and Sandwich isles. South of the equator are New Ireland, New Britain, Salomon, New Hebrides, Feejee, Friendly, Navigators, Society, Marquesas, Low, Cook or Hervey, and other minor groups. The population of the whole is vaguely estimated at from 1,000,000 to 1,500,000. The only European powers which have establishments in Polynesia are the Spaniards in the Mariannes, and the French in Tahiti and the Marquesas. The British have no settlements properly so called, but they exercise a great influence on the population by means of missionaries and agents.

In 1797, missionaries sent out by the London Missionary Society arrived in Tahiti, but they had little success in their labours till 1812, when Pomare the king determined to renounce his idols, and worship Jehovah as the only true God. His example was soon followed by the people. The inhabitants of Eimeo and of the Society Isles, Huaheine, Raiatea, Borabora, &c., also embraced Christianity. School-books, catechisms, and the Old and New Testaments, were printed in the Tahitian language, and the people made great progress in morality and religion. But the mission has of late years been brought to the brink of ruin by the French Government, which, contrary to the will of both the queen and the people, assumed what was called the *Protectorate* of the island, which in reality meant its oppression and subjugation.

In the Hervey Islands—including Rarotonga, Aitutaki, Mangaia, Atiu, &c.—the mission cause has made satisfactory progress.

When the American missionaries arrived in the Sandwich Islands in 1820, they learned that the king was dead, the Taboo broken, the priesthood abolished, and an incipient form of civilization apparent. In 1823, some of the natives were received into the Church, and in a few years a profession of Christianity became general both among the chiefs and people. Schools were established and numerously attended throughout the islands, in some of which a high order of education is given; and the whole Bible, school-books, almanacs, newspapers, and many other works, were printed in the language of the Sandwich Isles; a constitutional government was established, and laws were made securing the rights and liberties of all classes of the people. Their progress in civilization was long very slow; but of late they have made considerable advances. In January 1850 a census of the population was taken by the Government, when it amounted to 84,165; but now the deaths greatly exceed the births, and the population is rapidly decreasing. In May 1851, the total number of members received into the Church since the commencement of the mission was 39,201, and after deducting those deceased or excluded, there remained 21,054. The total number of children baptised was 14,173. The contributions of the natives for various Christian and benevolent objects, during the preceding year, amounted to 21,211 dollars (£4300). There were in 1851, 431 Protestant, and 104 Roman Catholic schools. In the former there were 12,976 scholars, and in the latter 2506—in all, 15,482. The whole expense for education in that year was about 60,000 dollars, of which about 45,000 were paid by the Government. This cheering state of progress has been much interfered with by the intemperance, licentiousness, and unjustifiable conduct of foreign residents and visitors, especially by the French Government and its agents in Tahiti.

The population of the Navigators Isles is estimated at 56,000; of whom, in 1852, 1420 were communicants, and 2856 were in attendance at school, under missionaries and native teachers of the London Missionary Society. In the Friendly Islands, with a population of about 19,000, there were, in 1852, 6987 church members under the Wesleyans, and 5007 scholars in the week-day schools. In the Feejee Islands there are 2322 church members, and 3333 children in the missionary schools.

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[1] Parliamentary Papers, 1853.

E U R O P E.

AREA, 785 SQUARE DEGREES, OR 3,768,000 SQUARE MILES. POPULATION, 265,357,785.[1]

		POLITICAL RELATIONS.					RELIGIOUS DISTINCTIONS.			
		STATE.	TITLE.	SQUARE MILES.	POPULATION.	DATE OF CENSUS.	PROTESTANT.	ROMAN CATHOLIC.	GREEK CHURCH.	JEWS.
GERMANIC OR GREAT GOTHIC STATES.	GREAT BRITAIN.	ENGLAND and WALES, **A**	Kingdom,	58,320	17,927,609	1851	17,500,000	400,000 ?	300	17,000 ?
		SCOTLAND,		31,324	2,888,742	...	2,770,000	100,000 ?		100
		IRELAND,		32,512	6,515,794	...	1,720,000 ?	4,785,000		
		ISLANDS,		394	143,126	...				
		NETHERLANDS (Kingdom of), with the Duchies of LIMBURG and LUXEMBURG, **B**	Kingdom,	11,610	3,302,625	1852	2,100,661	1,203,923	41	58,000
		DENMARK, with the Duchies of SCHLESWIG-HOLSTEIN and LAUENBURG, **C**	Kingdom,	21,650	2,296,597	1850	2,284,597	2,233		7,800
	SCANDINAVIA.	SWEDEN		170,096	3,433,003	1849	3,431,003	2,000		
		and **D**	Kingdom,							
		NORWAY,		122,000	1,328,471	1845	1,312,471	1,000 ?		
	THE STATES FORMING THE GERMANIC CONFEDERATION, INCLUDING PORTIONS OF AUSTRIA AND PRUSSIA, HAVE AN AREA OF 243,812 SQUARE MILES. POPULATION, 41,212,733.	ANHALT-BERNBURG, **E**	Duchy,	329	52,641	1852	49,547			837
		" DESSAU-KÖTHEN, (united in 1853),	......	651	111,759	1853	104,120	1,000		1,700
		AUSTRIA, including HUNGARY, GALICIA, LOMBARDY, and VENICE, **F**	Empire,	257,830	37,444,333	1851	3,501,455	26,357,172	6,856,761	729,005
		BADEN, **F 2**	Grnd Duchy,	5,904	1,362,774	1852	434,084	905,143		23,547
		BAVARIA, **F 3**	Kingdom,	29,637	4,559,452	1852	1,188,769	3,060,694		59,288
		BREMEN (Territory),	Free City,	84	79,047	...	78,047	1,000 ?		
		BRUNSWICK, **G**	Duchy,	1,531	270,825	1852	264,949	2,566		1,400
		FRANKFÜRT,	Free City,	38	77,930	1849	62,244	5,000 ?		5,000
		HAMBURG,	...	151	188,054	1850	173,054	5,000		7,000
		HANOVER, **H**	Kingdom,	14,846	1,819,253	1852	1,589,253	217,367		11,562
		HESSEN-CASSEL,	Electorate,	4,430	754,590	1846	750,590	4,000		
		" DARMSTADT	Grnd Duchy,	3761	854,314	1852	607,782	217,798		28,734
		" HOMBURG,	Landgrave,	206	24,920	1852	20,203	4,000		
		HOHENZOLLERN, HECHINGEN, and SIGMARINGEN,	Principality,	452	65,574	1851	25,574 ?	40,000 ?		
		LIECHTENSTEIN,	Principality,	53	6,351	1849		6,351		
		LUBEC,	Free City,	111	54,166	1851	46,642	2,000		
		MECKLENBURG-SCHWERIN,	Grnd Duchy,	4,845	542,763	1852	538,844	687		3,232
		" STRELITZ, **I**	...	767	99,628	1852	93,292	100 ?		900
		NASSAU, **J**	Duchy,	1,751	429,669	1852	224,753	186,998		6,871
		OLDENBURG, with Lordship of KNIPHAUSEN, &c., **K**	Grnd Duchy,	2,421	281,923	1852	154,110	65,470		709
		PRUSSIA, **L**	Kingdom,	107,938	16,346,625	1849	10,031,306	6,079,613	1,269	218,998
		REUSS-GREITZ, and REUSS-SCHLEITZ,	Principality,	562	112,175	1846	112,175			
		SAXONY, **M**	Kingdom,	5,770	1,987,832	1852	1,957,023	33,497	89	1,022
		SAXE-ALTENBURG,	Duchy,	510	131,700	1850	131,400	300		
		" COBURG-GOTHA,	...	790	150,412	1852	144,229	4,233		1,200
		" MEININGEN,	...	971	166,364	1853	160,928	900		1,500
		" WEIMAR-EISENACH,	...	1,418	262,524	1855	249,316	10,600		1,454
		SCHAUMBURG-LIPPE, and DETMOLD,	Principalities,	644	137,000	1848	135,000	2,000		
		SCHWARTZBURG-RUDOLSTADT, and SCHWARTZBURG-SONDERSHAUSEN,	...	* 658	69,038	1852	60,000	150		170
					60,847	1852	60,000	53		194
		WALDECK,	Principality,	461	59,697	1852	56,919	899		500
		WÜRTEMBERG, **N**	Kingdom,	7,658	1,733,263	1852	1,203,939	517,999		11,974
		SWITZERLAND, **O**	Confedn. of Republics,	15,261	2,392,740	1850	1,417,474	971,820		3,146
	IBERIAN PENINSULA.	SPAIN, with the Islands, and Republic of ANDORRA, **P**	Kingdom,	182,750	14,216,219	1849		14,000,000		
		PORTUGAL, with Islands, **Q**	Kingdom,	36,125	3,814,771	1850		3,814,771		
		BELGIUM, **R**	Kingdom,	11,313	4,359,090	1849	14,500	4,313,640		30,000
		FRANCE, **S**	Empire,	207,232	35,783,059	1851	1,800,000	33,370,000		60,000
LATIN OR ROMAN STATES.	ITALIAN STATES.	MARINO (SAN),	Republic,	21	7,600	1852		7,600		
		MODENA and MASSA, **T**	Duchy,	2,129	586,458	1850	458	586,000		
		MONACO,	Principality,	53	6,800	...		6,800		
		NAPLES,	Kingdom of the Two Sicilies,	31,350	6,612,892	1851		6,612,892		
		SICILY,		10,536	2,091,589	1845		2,091,589		
		PARMA,		2,274	502,841	1852		497,000		
		PONTIFICAL STATES,		17,494	2,908,115	1843		2,708,115		10,000 ?
		SARDINIA, Continent, with Islands of SARDINIA and CAPRAIA,	Kingdom,	29,167	4,437,584	1852	25,000	412,084		500 ?
					552,665	1843				
		TUSCANY, with LUCCA,		9,177	1,854,649	1851	1,000	1,853,149		500
SCLAVONIC STATES.		GREECE, **U**	Kingdom,	18,244	1,002,102	1852	3,000 ?	25,000	974,102	
		IONIAN ISLES,	Republic,	1,096	220,000	1852			230,000	
		RUSSIA (in Europe), **V**	Empire,	2,089,930	54,092,300	1846	(See Note V.)			
		POLAND (Kingdom of),			4,810,735	1850				
		FINLAND (Grand Duchy),			1,412,315	...				
		TURKEY in EUROPE, including the tributary Principalities of MOLDAVIA, WALACHIA, and SERVIA, **W**	Part of the Ottoman Empire.	197,025	15,500,000	1844	(See OTTOMAN ASIA.)			

REMARKS.

A The total population of Great Britain and Ireland in 1851 was 27,475,271; in 1841 it was 26,868,910—the increase during ten years being, for England and Wales, 2,013,461, and for Scotland, 268,558. The population of Ireland in 1841 was 8,175,124, whilst in 1851 it was only 6,515,794—showing a decrease of 20 per cent, or more than a million and a half (1,659,330) in ten years.

ENGLAND.

From the census returns of 1851 it appears that there are in England and Wales 35 different religious communities or sects—27 native and indigenous, and 8 foreign. The relative numerical importance of the principal religious bodies may be estimated by the number of sittings provided by each. The total number of places of worship is 34,467, providing sittings for 10,212,563 persons, of which the Church of England *supplies* 5,317,915, and all the other churches together, 4,894,648. Among these the Wesleyan Methodists, original connection, contribute 1,447,580; Independents, 1,067,760; Particular Baptists, 582,953; Society of Friends, 91,599; Unitarians, 68,554; Presbyterians, 86,692; Roman Catholics, 186,111; Mormons or Latter-Day Saints, 30,783; Jews, 8438. On the census Sunday three millions and three quarters attended the Established Church, and three millions and a half all the other churches and chapels together.

The earliest educational seminaries in England were the endowed grammar-schools, commenced previous to the Reformation. The first effort to educate the lower orders was by the institution of the Society for Promoting Christian Knowledge in 1698, and the establishment of Sunday schools by Raikes of Glo'ster in 1781. This was followed by the week-day schools, on the Madras system, introduced by Dr Bell in 1798, and by the labours of Joseph Lancaster, which resulted in the establishment of the British and Foreign School Society, founded in 1808. The National School Society was founded in 1811. The first infant school was established in 1818; and the Ragged School Union in 1845. In May 1852 this valuable institution had 110 schools, 1650 voluntary, and 200 paid teachers; with 13,700 children. In 1852, there were one or more Ragged Schools in 30 towns in England, 6 in Scotland, and 4 in Ireland. In all, about 70 in Britain, with about 7,000 scholars.

Of the population of England and Wales in 1851 (17,927,609), Mr Horace Mann estimates that 4,908,696 children ought to have been at school; or, deducting those employed in factories, detained by sickness, or educated at home, the number would be reduced to 3,663,261. Making allowance for deficient returns, the numbers in attendance, according to his calculation, should have been, in 15,518 public schools, 1,422,982 scholars; in 30,524 private schools, 721,396 scholars; in 23,514 Sunday schools, 39,783 scholars; or in 46,042 schools in all, there should have been a total of 2,144,378 scholars; but on the day of the census the actual attendance was only 1,754,812. Mr Mann estimates that there are nearly one million (968,557) children not employed, and not detained by sickness, who do not receive any kind of instruction whatever. The assumption that 1 in every 8.36 of the population is actually at school is therefore founded in error. The period of attendance at school is very inadequate, and the qualifications of many of the teachers most defective. In 708 children's, and 35 public schools, the returns were signed by the master or mistress respectively with a mark.

SCOTLAND.

The total number of places of religious worship in Scotland, according to the census of 1851, is 3395, with 1,834,805 sittings. Of these the Established Church supplies 1183 places of worship and 767,088 sittings; United Presbyterian Church, 465 places of worship and 288,100 sittings; Free Church, 889 places of worship and 495,335 sittings; other churches, 858 places of worship and 284,282 sittings, including Roman Catholics, 117 places of worship and 52,766 sittings.

Popery was abolished in Scotland as a national church in 1560; yet in the seventeenth century it was dominant in the western portion of the country, and in the islands of Inverness and Ross shires. Its chief seat now is in the Hebrides, on the west coast and islands of Inverness-shire, and in the counties of Aberdeen and Banff. In the island of Barra fully one-half of the population is Roman Catholic.

Episcopalians are now most numerous in the districts where Episcopacy at one time predominated—Inverness-shire, and the neighbouring district of Strathnairn, the south-east of Ross-shire, in Fort-William and Appin, and in the vicinity of Dunkeld. There has been no Bishop of Caithness and Orkney since 1762. Irish immigration has greatly increased the number of Roman Catholics in the large towns.

In 1851 the number of public day-schools in Scotland was 3349, with 280,045 scholars; private day-schools, 1893, with 88,472 scholars. Of these there were supported by the Established Church 914 schools and 62,359 scholars; by the Reformed Presbyterian Church, 2 schools and 355 scholars; by the United Presbyterian Church, 61 schools and 5907 scholars; by the Free Church, 719 schools and 63,041 scholars; by the Episcopal Church, 38 schools and 2864 scholars; by Independents, 4 schools and 424 scholars; by Baptists, 1 school and 167 scholars; and by Roman Catholics, 32 schools and 5673 scholars. As the census is confessedly made up of loose estimates and imperfect returns, its statements cannot be relied on; and it is evidently a great exaggeration to suppose that 1 in 7 of the population is in attendance at school. The Gaelic language still prevails in the Hebrides and in the west and inland parts of Argyll, Inverness, Ross, and Sutherland shires; but it is rapidly receding from the lowland borders.

IRELAND.

The difficulty of ascertaining the proportions which the several religious denominations in Ireland bear to each other is greatly enhanced by the singular decrease of the population. The Religious Instruction Committee of 1834 give the following proportions:—

Established (Episcopal Church,)	792,064	adherents.
Roman Catholics,	6,427,742	"
Presbyterians,	642,356	"
Other denominations,	21,808	"
Total,	7,883,970	

Or, Roman Catholics, 6,427,742; Protestants, 1,456,228—the former being to the latter as 4½ to 1. These returns have been charged with omitting a great number of Protestants under the head "Other denominations." In 1834 the Protestants and Catholics were nearly equal in *Ulster*; whilst in *Leinster* the Catholics were nearly as 10 to 1; in *Munster* nearly 19 to 1; and in *Connaught* 21 to 1 of the Protestant population.

A careful examination of facts gives the following as the nearest approximation of the comparative numbers at the beginning of 1854:—

Roman Catholics,	4,500,000
Protestants,	2,015,794
Total,	6,515,794

There are 2769 Roman Catholic clergymen, giving a proportion of 1 to each 2353 of the Catholic population; and 2261 Episcopalian clergymen, being nearly 1 to every 350 of the Episcopalian population.

The following shows the total number of Protestant ministers in Ireland:—

Episcopalians,	2261
Presbyterians,	663
Methodists,	248
Congregationalists,	25
Baptists,	16
United Brethren,	12
Total,	3224

—being 455 more than the whole of the Roman Catholic clergy, and in the proportion of 1 Protestant minister to each 2021 of the entire population, or 1 to each 508 Protestants.

By an Act passed in the reign of Henry VIII., it was ordered that each incumbent in Ireland should keep a school in his parish; and by another, in the 12th year of Queen Elizabeth, that every beneficed clergyman should endeavour to teach the English tongue to all and every one under his rule. These Acts were renewed and extended in the reigns of William III. and George I. For nearly the whole of last century, the Government of Ireland laboured to promote Protestant education, and no other. In 1733 the Charter Schools were established, for instructing the children of Roman Catholics as Protestants; but having given no satisfaction, the grants for their maintenance were gradually reduced, and withdrawn altogether in 1832. The Kildare Place Society, instituted in 1811, for the purpose of assisting schools with grants, establishing model schools, and publishing useful books, was, after 1812, assisted by Government grants. Its system required that the Bible or Testament should be read without note or comment. On inquiring into the state of the schools in 1824, the commissioners recommended that grants of public money, for the education of the poor, should be vested in a board nominated by the Government; and accordingly, in 1833, it was replaced by the present national system, the benefits of which seem now to be appreciated and taken advantage of by nearly all parties in equal proportions. From the Eighteenth Report of the Commissioners, it appears that, on 31st December 1850, the number of schools in operation was 4547, attended by 511,239 children. The schools in 1851 were 4704, and attended by 520,401 children—the increase during the year being 157 schools, and 9162 pupils. On 1st November 1852 the number of schools in operation was 4795. The average number of pupils to each school was 100½. Total number of teachers, male and female, at 31st March 1852, 5822. Of these there belonged to the Established Church, 360; Presbyterian Church, 769; other Protestant Dissenters, 40. Protestants of all denominations, 1169; Roman Catholics, 4653. Of the managers of the National Schools considerably more than one-third are Protestants. Of schools, more than one-fourth are under Protestant management. Of children on the rolls (31st March 1852), nearly one-seventh are Protestant; of teachers, one-fifth; and of applicants for grants, one-fourth.

B KINGDOM OF THE NETHERLANDS.

More than half the population, including the royal family, belong to the Netherlands Reformed Church. In a religious point of view, the population may be divided as follows:—

Netherlands Reformed Church, about	1,600,000
Separatists,	42,000
French, English, and Scottish Churches,	10,000
Lutherans,	54,000
Lutheran Separatists,	9,000
Baptists,	38,000
Arminians,	3,000
Jews,	56,000
Roman Catholics, with 1,542 priests, and 634 churches,	1,203,923

The Netherlands Government pays great attention to the subject of education. It is not compulsory; but parents, whose children are not sent to school, are uniformly denied relief from the Government funds. There is a normal school in almost every town of importance. Teachers are well paid. All parents who can afford it are required to pay a small sum; otherwise education is gratuitous. The result is, that nearly every child of the age of ten years is able at least to read and write.

C DENMARK.

Nearly the whole population belongs to the National Church—the Evangelical Lutheran Confession—to which, according to a recent law, the sovereign must conform. During two centuries every other communion was excluded; but the rigour of this law was gradually relaxed, and since 1849 all other communions are admitted on equal terms. Owing to the restrictions that existed previous to 1849, there are in all Denmark only about 2000 Roman Catholics, about the same number of Calvinists, 6000 Jews, 200 Mennonites, and 29 Anglicans. Hitherto the Roman Catholics have been limited to Copenhagen. No member of any Popish order is permitted to settle in the country—an exclusion specially directed against the Jesuits.

Denmark is one of the best generally educated nations in Europe. The *primary* schools are supported by the communes, and attendance at them is compulsory—infringement of the law involving the penalty of imprisonment, with bread and water or hard labour. They are nearly gratuitous; and so well is the law obeyed, that every man in the country has been taught to read and write; but as the gratuitous system appears to fail in creating a desire for more extensive learning, the limited amount of knowledge thus acquired is frequently forgotten from disuse. The *secondary* schools are supported by the Government, and attendance at them is voluntary and not gratuitous. About twenty of these higher schools are distributed over the kingdom. Formerly the instruction was purely classical; but recently they have embraced some of the modern languages and a few of the sciences. The instruction given is of the greatest excellence; and at present a race is being educated, of whom Denmark may well be proud.[1]

The communal schools were distributed thus in 1837—Denmark Proper, 2500; Duchy of Schleswig (1839), 687; Holstein, 975; Lauenburg, 100—4262 in all.[2]

D SWEDEN AND NORWAY.

Norway is an independent kingdom, united with Sweden under the same sovereign, the government being a limited hereditary monarchy. The Evangelic Lutheran Confession is the religion of the state, in the practice of which professors are obliged to bring up their children. Lutherans alone are eligible to hold office under Government. All other forms of religion are tolerated, except *Judaism*, which is strictly prohibited; but no Jesuits, or other monkish orders, are permitted to settle in the country. Roman Catholics have been admitted to Sweden only since 1781. Their number in 1851 was reckoned at 2000.

Education has made great progress—attendance at school being nearly the maximum of the juvenile population. It is affirmed that in Sweden[3] there is not one person in 1000 who cannot read and write; and Blom[4] asserts that scarcely a peasant is to be found in Norway but who can read, write, and cast some accounts, while many are much more advanced.

E GERMANIC CONFEDERATION.

The Germanic Confederation is composed of forty sovereign states, of which thirty-six are monarchies, and four republics (free cities). Among the monarchical states are 1 empire, 5 kingdoms, 7 grand duchies, 9 duchies, 11 principalities, 1 landgraviate, 1 electorate, 1 lordship. As shown by colours on the map, Protestantism prevails in the northern states; while Popery increases on proceeding southwards. Lutheranism is the prevailing form of the Protestant faith in Germany; but of late years *Rationalism* has made fearful inroads on the population.[1] In the Table, the *German* and *Greek* are merged with the *Roman* Catholics. The Mennonites and Herrnhutters, or Moravian Brethren, are classed with the Protestants. The whole population of the German states is thus divided, approximately, as follows:—Roman Catholics, 37,758,397; Protestants, 24,547,450; Greek Church, 6,858,059; Jews, 1,166,877.

F The population of Austria, according to difference of religion, is more particularly stated thus—

Roman Catholic,		26,357,172
Greek Church,	Greek Church,	3,694,906
	Greek Nonconformed,	3,161,855
Protestants,	Of the Augsburg Confession,	1,299,799
	Reformed,	2,161,765
Unitarians,		50,341
Other sects,		2,300
Jews,		729,005

The adherents of the Reformed Church are found chiefly in Hungary and Transylvania, and the Nonconformed Greeks in Southern Hungary, the military frontier, Transylvania, Bukovina, and Dalmatia.[2] Protestantism appears to be on the increase in the northern portion of the empire. In 1781 the number of Protestants in Bohemia was reckoned at 44,212; whilst in 1851 their number was 88,500[3]—having doubled in 70 years. In 1848, Cracow contained 17,846 Jews.

Education has made rapid strides in Austria—the law requiring that, in every province of the vast empire, every child between the ages of six and twelve shall be educated either in the school or at home. In the manufacturing districts, no child is allowed to be sent into a factory before completing its ninth year. After that age, children in factories are compelled to attend classes on Friday evenings and Sunday mornings till they have attained their fifteenth year. In Roman Catholic districts the school inspector is the priest, and in Protestant districts the dissenting minister. In 1842, the population of Austria, including Lombardy, but excluding Hungary, amounted to 25,304,152; and for this population there were provided 20,293 *primary* day-schools, or 1 for every 1247 of the population; besides 11,140 evening-class schools. The 20,293 primary schools had 41,869 teachers, or 1 for every 690 of the population. In addition to these there were 8 universities, 20 academies, 12 lyceums, 49 theological colleges, 53 philosophical colleges, 188 gymnasia or public schools, 126 special schools, and 1252 private schools. These had in regular attendance 155,746 pupils.

F 2 In Baden, the greatest attention is paid to the training of youth. No child may be employed in any factory until it has completed its eleventh year. In 1843, for a population of 1,335,200, there were—

Primary Schools.	Roman Catholic,	1,349
	Protestant,	573
	Jewish,	49
	Total,	1,971

—or 1 school for every 677 of the population.

F 3 In Bavaria the majority of the people, including the royal family, are Catholics. The Protestants are divided thus—Lutherans, 1,181,216; Reformed, 2717; other confessions, 4836.

Education is compulsory: every village has a good schoolhouse, and at least one accomplished teacher. The instruction of the people is as much attended to as in Prussia. In 1846 there were 8 normal colleges, with 696 students; 7353 schools, with 556,239 pupils; 8978 Sunday and Friday classes, for factory children and others, with 565,876 pupils, and 8797 teachers; 615 industrial schools, with 2517 teachers, and 88,861 pupils—giving 1 school for every 603, and 1 teacher for every 508 of the population.

G The great majority of the population of Brunswick, including the reigning duke, are Lutherans, there being only about 100 Moravians.

H The Protestant population of Hanover comprises—Lutherans, 1,494,033; Reformed, 93,220; Mennonites, Moravians, &c., 1071. Public instruction is placed under a superior council. In 1845 there was 1 university (Gottingen), 17 gymnasia, 13 higher schools, 5 normal, and 3561 town and country schools. The Catholic population of Hessen-Darmstadt is mostly limited to Rhenish Hessen. The majority of the population is Lutheran. The kingdom has a university at Giessen, and several seminaries. Primary education in Hanover, Hessen-Darmstadt, Hessen-Cassel, Gotha, and Nassau, is conducted on the Prussian system; and is nearly as efficient, and as widely diffused, as in that country.

I In Mecklenburg-Schwerin, the Protestant population, including the Grand Duke, is nearly all Lutheran—there being, besides, only 185 Reformed. There are a few Roman Catholics in Strelitz and Furstenburg.

J Among the minor creeds in Nassau there are 154 Mennonites, 337 German and Free Catholics, and 103 Lutherans. The majority, including the Duke, belong to the Evangelical (Reformed) creed. Education is equally advanced as in Prussia.

K The Protestant population of Oldenburg is almost entirely Lutheran, there being only 299 Reformed, and 42 Mennonites.

L Prussia had, in 1849, 9001 Protestant churches for 10,031,306 adherents, or 1 church for 1113 adherents, and 1 clergyman for 1627 of the population; 7238 Roman Catholic churches for 6,079,613 adherents, or 1 church for 840 adherents, and 1 priest for each 1082 of the population; 3 Greek churches for 1269 adherents; 30 Mennonite chapels for 14,598 adherents; and 901 Jewish synagogues for 218,998 adherents. Nearly two-fifths of the Jews are located in the province of Posen.

Since the peace of 1815, vast progress has been made in the instruction of the people in Prussia, and education, to the extent of reading, writing, casting accounts, and singing, is universal among the entire population under thirty years of age. Parents and guardians are compelled to send all children to school as soon as they have completed their fifth year, and to keep them there till they have attained their fourteenth, unless satisfactory evidence be produced that an equally efficient education is provided at home. A law of 1839 enacts, that no child may be employed in mining or manufacturing until it has completed its ninth year, and not then unless it has had three years of regular instruction, except where the miner or manufacturer establishes a school, and provides a qualified teacher. No teacher is appointed unless he can produce a teacher's diploma; and private schools may be opened only on condition of their being subject to public inspection. Previously, a small school-fee was charged; but at the revolution of 1848 this was abolished, and education is now entirely gratuitous.

In 1849, the number of children in Prussia between the ages of six and fourteen was 3,223,362. Of these, only 2,453,062 are returned as attending the primary schools. The difference, amounting to 770,300 is accounted for partly by the number who attend superior schools, or receive private instruction; and also by the fact of the Slavonic population in Bromberg and Marienwerder being unwilling to give their children a German education. The total number of primary schools is 24,201; male and female teachers, 30,865; scholars of both sexes, 2,453,062, or 101 pupils to each school, and 79 to each teacher. In 1843 it was calculated that one child in every six (6.5) of the population was receiving elementary instruction. At the Universities of Berlin, Bonn, Königsberg, Halle, Breslau, and Griefswalde, the higher branches of instruction are most ably conducted.

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[1] See the *Athenæum*, 1852, p. 1068.
[2] BAGGESEN, *Dänemark*, vol. i. p. 182.
[3] FORSELL, p. 280.
[4] *Der Königr. Norwegen*, p. 128.

[1] KRUMMACHER, in *Religious Condition of Christendom*, p. 424.
[2] STEIN, *Kleine Geographie*.
[3] Prof. ERHARD, in *Evangelical Christendom*, p. 441.

[1] The population here stated is the aggregate amount of the sums given in the fourth column. The proportions of the population in the division "Religious Distinctions" must be considered merely as an approximation to the truth. In many cases the numbers fall short of the actual population—1st, Because the calculations on which they are based are often of an older date than the census quoted; and, 2d, Because frequently a certain portion of the population is left unaccounted for even when the religious distinctions are given in a census.

M The Protestant population of Saxony comprised in 1848, 1,855,241 Lutherans, and 2582 Reformed Church. Among the Catholics were 1772 German Catholics. The royal family is Roman Catholic. The system of public instruction is the same as in Prussia, and education is equally well diffused. Every child is required by law to be under school training between the ages of six and fourteen. No child may be employed in a factory, or in other manual labour, until the completion of its tenth year. There were 9 normal colleges. The number of teachers was 2925, or 1 for every 588 of the population.

N WÜRTEMBERG.

The religion of the state and of the royal family is the Evangelical Lutheran. There are very few Protestants of the Reformed Church.

The education of the people is as much attended to in Würtemberg as in Prussia and Saxony; and school training, between the ages of six and fourteen, is equally compulsory. There is a celebrated university at Tübingen.

O The population of Switzerland, nearly the same in amount as that of London, is extremely diversified in its character. In French Switzerland three-fourths of the population is Protestant—the cantons Vaud and Neufchâtel being essentially so; whilst that of Geneva and the west part of Bern is mixed Protestant and Catholic, and Bas Valais is entirely Catholic. In German Switzerland the cantons Uri, Schwytz, Unterwalden, Zug, Appenzell, and Tessen, are almost entirely Catholic; while the others are more or less mixed. The relative number of Catholics has increased in some cantons, and diminished in others; so that the proportion remains nearly the same as it was previous to the accession of Vaud, Neufchâtel, and Geneva in 1815—that proportion being nearly as 3 Protestants to 2 Catholics. All forms of religion are tolerated. The Jews have a synagogue at Geneva.

Switzerland ranks among those countries which have done most for elementary education; and this is especially the case in the French cantons. Attendance at school, between the ages of six and fourteen, is compulsory in all the cantons except Geneva, Valais, Uri, Schwytz, and Unterwalden. In some of the manufacturing districts, children are not permitted to engage in factories until eleven years old. There are in Switzerland 13 normal colleges, and 5500 primary schools, with about 350,000 pupils—giving nearly 1 scholar for every 7 of the population.

P The religion of Spain is exclusively Roman Catholic, and there is little or no toleration for other denominations. The Jews were frequently subjected to cruel persecutions. In A.D. 621, 90,000 were baptised, and many escaped into France. They were finally expelled by Isabella in the year 1492, and are still rigidly excluded. Some are said to remain under the guise of Christians, although unknown to the Spaniards.[1] The population of Spain is stated on the authority of the Government returns; but there has been no actual census of the country since the year 1788. Education is extremely deficient, as shown by the latest estimates: Thus, of the thirteen millions comprising the computed population of the Peninsula, without the islands, only 1,898,288 are returned as able to read, and 1,221,001 able to write. School reform dates from 1845. The French method of public instruction has been introduced; and the Government is now engaged in attempts to raise the educational status of the country. At the end of 1851, Spain had 10 universities; 10 normal schools of the first class; 23 elementary normal schools at the expense of the state; 17,099 schools for boys, with 626,832 scholars; 5021 schools for girls, with 201,200 scholars; and 287 infant schools, with 11,000 children. The total number under instruction in the schools was 839,182, or about 1 in 16 of the population.[1]

Q The religion of Portugal is Roman Catholic; but Israelites and other denominations are tolerated. On account of its long unsettled political condition, education has been much neglected. The principal seat of learning is the University of Coimbra. There are in all about 873 schools in the country, in 263 of which Latin is taught: 27 are denominated lyceums, and 17 seminaries. In the capital are extensive libraries and literary institutions.

R The religion of Belgium is Roman Catholic, but the King is Protestant. Freedom of religious worship and of instruction is guaranteed since the revolution of 1830, and Protestantism is on the increase—about 20 new churches having been built by proselytes from Popery. In 1851 the Protestants were estimated to comprise—Church of England, 7 congregations, and 5000 adherents; Union of Evangelical Christians, French, German, and Dutch, 8 congregations, and 5000 adherents; converted Romanists, 15 congregations, and 4500 adherents. The Jews are distributed throughout all the provinces.

Education in Belgium is now placed under the direction of the priests. The compulsory system of instruction, in force under the Dutch rule, was abolished in 1830. By the census of 1846 it appears that the total number of children, between the ages of five and fifteen, under instruction, was 472,590—of whom 6682, or about 1 in 70, were educated privately. The average in the entire kingdom gives 1 pupil in 9 of the population. In the provinces of Namur and Luxemburg it is 1 in 7; and in West Flanders 1 in 12 or 13.

S The religious statistics of France refer to the year 1846;[2] consequently the total falls short of the population of 1851.[3] The religion of the majority is Roman Catholic; but all forms of worship are tolerated. The Protestants comprised 1,400,000 Calvinists, and 400,000 belonging to the Augsburg Confession. The Protestants of the Reformed Church are very unequally distributed: they are most numerous in the departments of the south, east, and west—(Gard, Lozère, Ardèche, Drome, Isère, Dordogne, Deux Sèvres, Haut and Bas Rhin, &c.); and thinly scattered in the north and centre of France. They are limited to 62 of the 86 departments. The Lutherans, or adherents of the Augsburg Confession, occupy only the eastern departments—(Bas and Haut Rhin, Doubs, H. Saône, Meurthe, Vosges, Moselle, Seine.) There are Independent, Presbyterian, and Congregationalist churches in 16 departments; and Plymouth Brethren in those of the south. The Wesleyans have 19 pastors, and 865 members, in 8 departments. The Baptists have 5 pastors, 6 churches, and 150 members. The Jews have about 60 synagogues, and 70 rabbins; they are most numerous at Metz, Strasbourg, and Paris, but are disseminated also through the departments of Alsace and Lorraine.

The system of national education in France was introduced by M. Guizot in 1833. Attendance at school is not compulsory; but each commune is required, by law, to support at least one primary school; and no child is permitted to be employed in the factories until it has attained the age of nine years.

Popular instruction is very unequally distributed in France; for, while in some departments it is almost complete, others are not half provided for. The best educated are the departments of the east, where, in 1848, the number of the age of twenty years able to read amounted on an average to 900 per 1000; while in the departments of the centre and west, the average was under 300 per 1000. In the east the number of girls attending school was only one-eighth less than the number of boys; while in the centre and west, the number of girls was not one-half that of boys. The number of children attending the primary schools of France in 1837 was 1,935,624; in 1847 this number had increased to 3,146,510. But although, at the period of the revolution of 1848, "Government had provided for a regular augmentation of the *material*, it had almost entirely neglected the *moral* part of education—leaving to its successors the task of increasing the number of schools and good teachers, organising the means of instruction for girls, the maternal schools, and those for adults."[1]

T ITALIAN STATES.

In Italy all are Roman Catholics except the Protestants of the Vaudois, and a few Greeks in Venice and Leghorn. There are Jews in all the large towns, but mostly in Rome, Leghorn, and Venice. It is calculated that there are 500,000 priests, or clergy, in Italy, or about 1 to every 40 of the inhabitants. The people generally are kept in a state of gross ignorance; few of the peasants can read, while of the mechanics in towns scarcely one can sign his name: but the kingdom of Sardinia forms an honourable exception. The Waldenses inhabit the valleys of Piedmont, in the north-west of this country, comprising a district about sixty miles in circumference. The population of the valleys is estimated at 27,500—of whom 22,000 are Protestants, and 5500 Roman Catholics. The Statistical Statement of 1848 gave 21,378 Vaudois, and 4462 Roman Catholics. Since their emancipation in 1848, their number has increased, by the return of many families who had expatriated themselves. The language in general use is French. There are in the valleys 164 primary schools, 137 of which are opened only from three to five months in winter; 15 regular parish schools, open ten months; 6 girls', and two infant schools; and a college with 3 professors." Government grants 2500 francs per annum for public instruction.

In Sardinia, all the university establishments, the secondary and elementary schools, are under the direction of a Minister of Public Instruction, appointed in 1847. There are 4 universities in the four cities of Turin and Genoa, on the continent, and Cagliari and Sassari, in the island of Sardinia. These had, in 1850, 3000 students. The Government pays great attention to the training of the children of the poor in elementary and industrial schools.

Tuscany has a university at Pisa, another at Sienna, and a lyceum at Lucca. Primary instruction is very limited. It appears, from recent returns, that beyond the principal towns there is a population of 273,586, between the ages of seven and eighteen, of whom only 12,173 males, and 4925 females, attend the public, and 5428 males, and 5741 females, the private schools; so that, of 272,586 young persons, 245,319 are destitute of all means of instruction. In 1849 there were in Florence 1418 Jews, and 901 Protestants.

Education is at a low ebb in the Pontifical States; not so much that schools are wanting, as that they are badly organised and exclusively under the dominion of the priests. Instruction is in general gratuitous, but very limited. It is calculated that Government provides instruction for about 1 in 50 of the population. The highest educational institute at Rome is the celebrated College of the Propaganda, for the training of young priests, the endowment of which is said, but without evidence of the fact, to be immense. The population of Rome (exclusive of visitors) in 1853 was 175,822, of whom 4500 were priests and friars, and 1900 nuns. The resident Jewish population is between 6000 and 7000, who are still compelled to live in the Ghetto, or Jews' quarter.

In the Kingdom of the Two Sicilies there are several universities; but in them education is so trammelled as to be of little use to the community. The people in general are amongst the most ignorant in Europe. The question of primary instruction is left to the consideration of the bishops of each diocese, with a recommendation that schools, on the plan of mutual instruction, should be established in the capitals of the communes; but at present there are no schools for the lower classes, and the few that exist are in the hands of an ignorant clergy.

Sicily has primary and secondary schools in each commune, colleges and academies in 21 towns, and the universities of Palermo and Catania have 81 professors; but with all this machinery the people, high and low, are extremely deficient in education.

U The Orthodox Oriental and Apostolic Church of the Kingdom of Greece acknowledges, as its spiritual head, "none other than Our Lord and Saviour Jesus Christ." It declares itself free and independent of any foreign power—recognising his Majesty the King of Greece as its temporal head. In 1845 there were 2905 parish churches, and 2123 priests and deacons. The priests are not allowed to marry *as such*, but may as deacons. There is no objection to married men becoming priests, but such cannot be raised to bishoprics. The numerous convents formerly existing in Greece were, in 1834, reduced to 138, containing 1646 monks, besides novices and servants. The nunneries were reduced to 4, with 151 nuns.

There is free toleration for all religions. In 1845 there were 4 Roman Catholic bishoprics, with 25,000 adherents. These were located mostly in the islands of the Archipelago, and were partly native families, and partly descendants of Genoese, French, and Venetians, who had settled at different periods. The few Protestants in Greece are mostly foreigners resident in the capital. The Queen is Lutheran, and the Protestant Germans worship in the royal chapel. There is at Athens an English Episcopal chapel. Several agents of British and American Missionary societies are settled in different parts of Greece; but their labours are confined to distributing the Scriptures and tracts, and establishing schools—all attempts at proselytism being strictly prohibited by the laws.

The few schools which existed at the close of the Greek Revolution, were annihilated during the reign of anarchy that preceded the establishment of the kingdom in 1832. The Royal Seminary for Schoolmasters was founded in 1834, with 8 professors. Up to 1839 it had given diplomas to 265 elementary teachers. In 1853 there were, according to the *Pandora*, a journal published in Greek at Athens, 338 communal schools for boys, with 366 teachers and 33,864 pupils; 31 communal schools for girls, with 40 teachers and 4380 pupils; 17 private schools for girls, with 1479 pupils; and a superior female school, with 13 teachers and 464 pupils.

Elementary instruction is more diffused in the islands than in the Peloponnesus or on the continent. The Morea, which contains about half the population of the kingdom, has scarcely one-third of the whole number of children at school. In continental Greece, elementary instruction has made still less progress, except in the capital. Still, considering the nature of the war in which the people of Greece have so long been engaged, and the short time that has elapsed since they began to enjoy the benefits of peace and of an organised government, it must be admitted that elementary education has made rapid strides, and that its present state is worthy of a nation thirsting for knowledge. Previous to 1821, Greece had no journal, nor even a printing-press. It had only 4 or 5 schools, at Siphnos, Missolonghi, Dimitzana, &c. Athens has now (1854) 19 printing establishments, and there are others at Syra, Nauplia, Patras, Tripolitza, and Chalcis. In the kingdom of Greece there are issued 22 newspapers, and 4 periodical journals. For about a million inhabitants, Greece has among its educational establishments 750 professors, and about 47,000 pupils. Many of those in the higher classes are from the Turkish provinces. Athens has a university, with 39 professors and 590 students; an observatory; 7 gymnasia or colleges, with 43 professors and 1077 pupils; a normal school, with 7 professors and 60 pupils; a theological seminary, and societies of natural history, archæology, and the fine arts.

The population of the Ionian Isles is chiefly of Greek descent. The educational establishments are—a university, a college, and an ecclesiastical seminary. There is a secondary school in every island, and primary schools in the larger villages.

V M. Tegoborski, in his recent statistics, gives, for European Russia, a population of 62,047,000; Asiatic Russia, 5,200,000. Adding, for Russian America, 60,000, and making allowance for the army in active service and the military marine, he is of opinion that the minimum amount of the population of the Russian Empire, in 1850, was 68,000,000.

The Russian Greek Church, of which the Emperor is head, is the state religion. The population of European, Asiatic, and American Russia is not distinguished according to religion in the official returns; but for the whole empire they are classed, approximately, thus:—

Russian Orthodox Greek Church,			49,000,000
Roman Catholic Church	In Poland, about	4,500,000	7,200,000
	In West Russia,	2,500,000	
	Dispersed,	200,000	
Protestant	Lutherans in Finland,		2,500,000
	" Russia,		
	" Poland,		
	Reformed Church in Baltic provinces,		
	Moravians in Livonia,		
Mohammedans in east and south,			2,400,000
Jews,			1,500,000
Armenian Catholics and Armenian Gregorians,			1,000,000
Idolators.	Buddhists and the worshippers of the Grand Lama in S.E. of Siberia,		600,000
	Shamans, in Siberia, and among the Samoides and Lapps,		

The official report on education for 1851 declares that "religious training constitutes the only solid basis of useful instruction." All teachers are placed under the surveillance of ecclesiastical inspectors. The superior establishments comprise, the pedagogical institute of St Petersburg, 6 universities, and 3 lyceums; with a total of 3521 students.[1] There are 2149 secondary establishments, with 116,936 pupils.[2] Total, 121,457.

In the kingdom of Poland, there are 1561 institutions, with 82,942 pupils.[3] Besides these establishments for the Christian community, there are a certain number of schools specially for the Israelites, who form a separate community in the state. Private education does not flourish, there being only 2260 male and female teachers under this category.

The military schools constitute an administration apart, under the personal direction of the Emperor, who has introduced great improvements in regard to moral as well as scientific and practical instruction. Total number of military schools, 27, with 9304 pupils.

In 1824, the estimated number of children receiving instruction was, in comparison to the entire population, as 1 in 300. In 1843 the number of schools in European Russia, exclusive of Poland, was said to be 3300, and the number of pupils 1,800,000, giving a proportion of about 1 in 31 of the population; and, "considering how many centuries the other states of Europe are in advance of Russia in regard to mental cultivation, it must be admitted that Russia has done more, in proportion, for the progress of education, than any other country in Europe."[4]

From another estimate, the same author calculates that now (1854) "the proportion of pupils to the entire population is as 1 to 151; whilst in Germany, the proportion is as 1 in 6 or 1 in 9."[5]

W TURKEY IN EUROPE.

The numbers given in the Table as pertaining to the Greek Church in Turkey include the adherents of all the eastern churches, however differing in ritual. They also comprise the adherents of the Greek Church in Bosnia, Albania, Croatia, &c. The great body of the adherents of the eastern churches, including the Greeks, do not acknowledge the Holy See.—*See* Remarks on Ottoman Asia.

Public instruction in Turkey was remodelled in 1847. It now comprises: 1. *Elementary Instruction*—reading, writing, ciphering, and religion. 2. *Middle Schools*, for Arabic, orthography, composition, religious history (Islam.), Turkish and universal history, geography, arithmetic, and geometry. 3. *Colleges*—embracing a normal school, medical school, military college, artillery college, naval college, agricultural and veterinary colleges. Instruction is gratuitous, and parents are obliged to send their children, of either sex, to school on attaining their sixth year. There are 40 public libraries at Constantinople, where government has three printing establishments, besides two belonging to Europeans, and where thirteen journals are published in six different languages.

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[1] Borrow's *Bible in Spain*.

[1] *Spanien*. Von Dr Minutoli. 8vo. 1852. P. 131.
[2] Schnitzler, tom. ii. p. 120.
[3] A census of religious bodies was lately ordered by the Emperor of France; but its results are not known.

[1] M. Allard, *Ann. de l'Econ. Polit.*, June 1849.

[1] Being 233 under 1849.
[2] Being 3656 more than 1849.
[3] Being 1279 more than 1849.
[4] F. W. von Reden, *Das Kaiserreich Russland*, p. 331.
[5] *Ibid.* Russland's *Kraft-Elemente*, 1854.

(*Explanation of the Map in the left corner of the Sheet.*)

CLASSIFICATION OF THE PEOPLE OF EUROPE
ACCORDING TO LANGUAGE.

This Map is Coloured so as to indicate the existing distribution of Languages in Europe, comprising Four Great Families or Divisions, namely, the GRECO-LATIN, the GERMANIC or GREAT GOTHIC, the SLAVONIAN, and the KELTIC (or CELTIC), with their Subdivisions.

I.—(1.) THE GRECO-LATIN Family comprises the *Romaic*, or *Modern Greek*, in the Kingdom of Greece, especially the south portion, the Archipelago, and part of Asia Minor. (2.) The LATIN or ROMAN branch comprises the *Italian* in the peninsula of Italy, part of Switzerland, and in some of the islands of the Mediterranean;[1] *Spanish*, or *Castilian*, in the greater portion of the Iberian Peninsula, except the Basque provinces; *Portuguese* in Portugal and the islands of Madeira; *French* in France, a great portion of Belgium, and in part of the west and south of Switzerland. The *Provençal*, once the common and poetic language of the whole of southern Europe, is now confined to the districts of the lower Rhone. *Wallachian*, or *Wallack*, which bears the same relation to the Roman as the French to the Roman and Celt, or the Spanish to the Roman and Iberian, is spoken by the Rumanzi of the Danubian Provinces of Moldavia and Wallachia.

II.—THE GERMANIC OR GREAT GOTHIC FAMILY.—The German language is spoken in the countries extending between the northern slope of the Alps and the German Ocean and Baltic Sea, in German Austria, the east of Switzerland,[2] and part of the French departments on the Rhine. Its chief dialects are the *Alemannic*, in the districts of the upper Rhine; the *Suabian*, on the upper Danube and the upper Neckar; the *Bavarian*, on the Danube and its southern tributaries the Isar and the Inn; the *Franconian*, in the north, on the middle Rhine and the Maine, to the south-west declivity of the Thuringian forest; the *Thuringian*, or *Hessian*, north-east of the Thuringian forest to the Saale and the Bode. The inhabitants of the Rhenish provinces of Prussia have a mixed Alemannic and Franconian dialect, the latter of which is spoken by an original Franconian missionary colony inhabiting an isolated portion of the Harz, in the vicinity of Goslar.[3] Beyond the Saale, on the middle Elbe and Oder, a mixed dialect of Franconian, Thuringian, and Saxon is spoken. Early colonisation from western Germany was chiefly directed to eastern Europe; hence the German populations of the Baltic provinces of Russia, the Germanising of eastern Prussia, and the existing German colonies of Hungary and Transylvania. In all north Germany the dialects are the *Saxon* and the *Frisian*, to the latter of which belongs the *Dutch*, spoken in the whole of the Netherlands, and the *Flamandish*, or *Flemish*, a dialect of the Dutch, spoken by a large proportion of the people of Belgium—a country which presents a striking example of the permanency of language; for the line of demarcation between the French and Flemish speaking populations of Belgium, in spite of the attempts of several governments to efface it, has remained almost invariably the same. In 1846 the proportions of the population speaking the different languages or dialects were—French or Walloon, 1,827,141; Flemish or Dutch, 2,471,248; German, 34,000; English, 3821; other languages, 923. The French and Flemish, with their dialects, are almost the only languages spoken in Belgium. The Flemish predominates over the French in the proportion of four to three, nearly. The provinces of east and west Flanders, Antwerp, Limburg and Brabant are those in which Flemish is mostly spoken; but in Brabant a considerable number speak French, or rather Walloon. German is the language of a portion of Luxemburg.[4] The *Scandinavian*, or *Old Norse*, is the language of Norway, Sweden, and Denmark. *Swedish* is spoken on the east side of the peninsula, and in the larger towns of Finland; *Danish* on the north of the Eider, in the peninsula of Jütland, the Danish archipelago, and Bornholm; *Icelandic* in Iceland.[5] *English* in England, the southern, central, and eastern portions of Scotland,[1] in part of Wales, and in the eastern portion of Ireland.[2]

III. The SLAVONIAN family belongs especially to the east of Europe. Mixed with Roman and German elements, it extends from the Böhmerwald Mountains and the Gulf of Istria on the west, to Siberia on the east. The dialects of the south-east Slavonians are the *Russian*, which prevails almost exclusively over the great plain of North-eastern Europe; the *Russniak* in Galicia, Hungary, &c., and in the Russian Governments of Volhynia and Podolia; the *Bulgarian*, *Servian*, *Dalmatian*, *Croatian*, and *Bosnian*, in the districts of the Lower Danube, on the Drave and Save, and on the west coast of the Grecian Peninsula; and the *Wendish* in the middle of Lower Germany, on the Upper Spree. The north-western dialects are the *Polish*, in the districts of the Niemen, Vistula, and Wartha, except in the low grounds; the *Bohemian*, or *Czechian*, in Bohemia and Moravia; the *Slowakian* in the West Carpathians, and on the Waag, Neutra, and Gran. To the same family belong the *Lettish*, on the coast lands of the Baltic, between the Curische Haff, the Gulf of Finland, and Lake Peipus; and, mixed with Polish, Russniak, and German elements, in the districts of the lower Duna, the Niemen, and the upper Pregel;—and the *Lithuanian*, in the Russian Governments of Wilna, Grodno, Minsk, Smolensk, &c.

IV. The KELTIC family comprises the *Armoric* or *Bas Breton*, in the province of Bretagne, in the west of France, where the *Keltic Breton* continues to be the language of the common people; the *Gaelic* in the west of Ireland, the oldest and purest in Britain; the *Gaelic* of the Highlands and Western Islands of Scotland, which is more mixed with English and Scandinavian elements; the *Manx* of the Isle of Man, where a language is still spoken in so far resembling the Gaelic of Ireland and Scotland as to be mutually intelligible; and the *Cambrian*, or Cambro-British of Wales, forming a separate branch of the family, not intelligible to any Gael.

In the Keltic family is sometimes, doubtfully, included the *Basque*, or *Iberian* of the West Pyrenees (Gascogne in France, and Biscay in Spain), a language which is supposed to have at one time prevailed over the whole Peninsula, and in France as far as the Rhone and Garonne, and which, according to Latham, has the same relation to the ancient language of the Spanish peninsula that the present Welsh has to the old speech of Britain, representing it in fragments, the preservation of which is due to the existence of a mountain stronghold for the aborigines to retire to; and so complete is this isolation, that no language in the world is placed in the same class with the Basque. Another peculiar, isolated, and unclassed language is the *Albanian* of Albania, which is as different from the Greek, Turkish, and Slavonic tongues of the countries in its neighbourhood, as the Basque is from the French, Spanish, and Breton, and it is equally destitute of relations at a distance. The *Magyar* of Hungary and Transylvania is supposed to have been imported from the vicinity of the Caspian Sea, and has a great resemblance to the *Finnish* and *Lapponic* languages of the north-east of Europe.—(See further in Notes to "Ethnography of Europe," p. 108.)

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[1] In Malta the labourers still speak Arabic, although surrounded with Italian, English, and a *Lingua Franca*.—LATHAM.

[2] The proportion of the population in Switzerland speaking different languages is nearly as follows: German, 1,720,000; French, 489,000; Italian, 143,500; Romande, 45,240.

[3] KUTSCHEIT.

[4] QUETELET.

[5] "The Icelandic language has altered so little within the last one thousand years, that it is nearly the same as that of the old sagas and poems; sagas and poems which every Icelander can read. On the other hand, the change on the Continent has been so great that no modern dialect of Norway, Sweden, or Denmark, is intelligible to an Icelander."—LATHAM, *Ethnology of Europe*.

[1] The *Norse*, which long survived in Caithness and the Orkney and Zetland Islands, gave place to the English, now the prevailing language of these countries.

[2] "The English language seems chosen, like its people, to rule in future times in a still greater degree in all the corners of the earth. In richness, sound reason, and flexibility, no modern tongue can be compared with it."—GRIMM.

ASIA.

AREA, 3,400 SQUARE DEGREES, or 16,915,227 SQUARE MILES. POPULATION, 652,500,000?

	POLITICAL RELATIONS.					RELIGIOUS DISTINCTIONS.					
	STATE.	TITLE.	SQUARE MILES.	POPULATION.	DATE OF ESTIMATE.	PROTESTANT.	ROMAN CATHOLIC.	GREEK CHURCH.	JEWS.	MOHAMMEDAN.	PAGAN.
	ARABIA, . . . **A**	Several Chiefs,	1,200,000?	8,000,000?	1850	5,000?				7,795,000?	
	CHINA PROPER, including the Islands FORMOSA, HAINAN, LOO-CHOO, . **B**	Empire,	1,700,000?	360,000,000?	...		320,000?		1,000?		360,000,000
	CHINESE EMPIRE, assumed Dependencies of TIBET, MONGOLIA, MANTCHURIA, KOREA, . . .	Empire,	3,600,000?	35,000,000?							35,000,000?
	JAPAN, . . . **C**	Empire,	266,500	30,000,000							30,000,000
FARTHER INDIA, OR INDIA BEYOND THE GANGES.	ANAM, or COCHIN-CHINA, with TONQUIN and part of CAMBODIA, . . **D**	Kingdom,	140,000?	6,000,000?						500,000?	5,500,000?
	BURMAH, and part of	Empire,	255,000?	8,000,000							Buddhists.
	CASSAY, or CATHI,		3,000?	30,000?							
	MALAY PENINSULA,		45,000?	375,000		3,000?	2,000?			370,000	
	SIAM, ...	Kingdom,	220,000?	4,500,000?							
	AFGHANISTAN, . **J**			5,120,000	1844					5,120,000	
	BELOOCHISTAN, **K**		160,000?	400,000	1844					400,000	
	KAFIRSTAN, . **L**		7,000?	Not known.							Pagans.
INDEPENDENT TARTARY OR TURKESTAN.	BOKHARA, . . .	Khanat,	233,000	1,000,000?						100,000?	
	KHOKAN, . . .	Khanat,		500,000?						500,000?	
	KOONDOOZ, . **M**		485,000?	200,000?							
	Kirghiz, Desht.,										
	PERSIA, or IRAN, **N**	Empire,	450,000?	8,000,000?			100,000	200,000?	100,000?	7,000,000	600,000?
BRITISH POSSESSIONS IN ASIA. HINDOSTAN. British India. Area, [illegible] sq. miles. Pop. [illegible]	BENGAL PRESID., **O**		225,652	47,958,320	1852						
	NORTH-WEST PROVINCES, . . .		85,571	23,200,543	...			See	Note	O.	
	MADRAS PRESIDENCY,		144,889	16,339,426	...						
	BOMBAY PRESIDENCY,		120,065	11,109,067	—						
	NATIVE STATES in										
	BENGAL, . .		502,518	43,009,862	1853						
	MADRAS, . .		51,802	4,752,975	—						
	BOMBAY, . .		57,375	4,233,400	—						
	CEYLON, (Island,) **P**		23,210	1,500,000	1848						
FARTHER INDIA.	E. STRAITS SETTLEMENTS—TENASSERIM, PULO PENANG, PROVINCE WELLESLEY, and Islands adjacent, . **R**		1,873	282,540	1832						
	E. ARCHIPELAGO and MALACCA,		900	50,000							
	SINGAPORE, . .		270	57,421							
CHINA SEA.	LABUAN, . . .			1,000				See	Note	R.	
	HONG KONG, . .		230	25,000							
FRENCH POSSESSIONS IN INDIA.	CHANDERNAGOR,		188	31,447	1849						
	KARIKAL, . . .			56,583	...						
	MAHÉ, ...			3,341	...						
	PONDICHERRY, . .			81,154	...						
PORTUGUESE ASIA.	GOA, DAMAUN, DIU, &c., (in India,) .		800	400,000?							
	Settlements in the islands SOLOR, TIMOR, MISORA, . . .		660,000?	220,000?							
	MACAO (China,) .		12	33,000							
RUSSIAN ASIA.	SIBERIA, . **S**	Empire,	5,498,759	2,937,000	1846			See	Note	S.	
	TRANSCAUCASIA, &c.			2,648,000	...						
OTTOMAN ASIA.	ASIA MINOR, .	Empire,	508,800	16,050,000	1844		640,000	2,360,000	100,000	12,950,000	
	SYRIA, ...										
	MESOPOTAMIA, .										
	ASSYRIA, . **T**										

REMARKS.

A MOHAMMEDANISM had its origin in Arabia in the year 622, when it replaced Sabaism and Judaism, which had previously been the prevailing forms of worship. A great portion of Arabia, especially that which contains Mecca and Medina, belongs to Turkey. The interior of the peninsula is occupied by miserably small states, more or less independent. The most important of these, the Imaum of Muscat, holds commercial relations with England and France, the former having a resident at his court. The Imaum is priest as well as sovereign; his authority extends over part of Moghistan, the isles of Kishma and Ormus in the Persian Gulf, and the island of Zanzibar, with several stations on the east coast of Africa. The Arab population of his dominions is estimated at 850,000. The *Wahabees* are a distinct sect of Mohammedans.

B The Chinese race forms the basis of the population of the empire, the Mongols and the Mantchoos, who have successively usurped it, being few in number. The Mantchoos, the present dominant race, have profited by Chinese civilization. The Mantchoo is the idiom of the court, and, along with the Chinese, is the official language; but the Chinese is the dominant language, being that used in education, science, and books. The Chinese government is an absolute monarchy. The sovereign is styled the "Son of Heaven;" he is the chief of the official religion, that of Confucius, which is adopted by the court of Pekin and by the upper classes. Buddhism is the religion of the great mass of the people of China Proper, Mantchooria, and Tibet, which latter country is its head quarters, being the seat of its most sacred *lamas*, or priests, upwards of 80,000 of whom are supported by the Government. The Taou religion ranks next in the number of its votaries. Mohammedans are said to be numerous in the province Shensi, and they form the majority of the population in Chinese Turkestan. There are supposed to be 320,000 Roman Catholics, and a small number of Jews, in the Chinese empire. In 1844 there were 13 Roman Catholic bishops and 170 priests in China. Protestant missionaries have also been sent to China. The New Testament was published in Chinese in 1814, and the Old Testament in 1823. In 1845 an imperial rescript was issued, tolerating the Christian religion; and since then, Protestant missions have been established at the five free ports, and also at Hong Kong. The missionaries are, generally speaking, well treated by the Chinese, and have good opportunities of making the Gospel known to them. The Roman alphabet for writing the spoken language has been attempted to be introduced, but its success is very doubtful.

Science is the basis of the social organization of the Chinese, the scholars or learned men being always alluded to as a separate class in public documents. It has been asserted that there are few countries in the world where education is more widely disseminated; that the only distinctions in the empire are founded upon it; and that its rewards are obtained only by long study and frequent examinations. But the trustworthy evidence of Protestant missionaries shows that reading is by no means general among the Chinese. Of the common people very few men can read intelligibly the easiest book; and it is so rare to find a woman who can read, that it may be said the path of learning is entirely closed to them.

C JAPAN.

Japan is the most isolated state of the world. Denying intercourse with nearly all Europeans or Americans, its inhabitants are yet not destitute of cultivation; they have long known the art of printing, but without making use of moveable types; they have a literature, and science is not altogether unknown to them. Since the expulsion of the Jesuits in 1632, only one European people, the Dutch, have been permitted to share with the Chinese the commerce of Japan. By an authority granted in 1641, the Dutch have an establishment at Decima, a small artificial island, opposite the town of Nagasaki. The Japanese are of the Mongolian race; their government is despotic, and is shared by ecclesiastical and military sovereigns. Their laws are very rigorous. Their ancient religion is that of the Sin-sin, whose priests were said to be descended of the sun; but the majority of the population are adherents of Buddhism, introduced into Japan about the sixth century of our era, though some profess the doctrines of Confucius.

D–I Farther India, or the region extending from China to the Bay of Bengal, south of the mountains of Tibet, comprises many nations, exhibiting a great variety in their state of comparative civilization. In Burmah the rudiments of education are widely diffused; most of the men, even common labourers, learn to read and write a little; but printing is unknown, and books are consequently scarce—the mass of the people having nothing on which to exercise their acquirements, except short written instruments used in the transaction of business. Their religion is Buddhism, which is understood to have been introduced about B.C. 443. Having a regular government, a written language, and an established literature, Burmah is entitled to be called a civilized country. An American Baptist Mission was commenced at Rangoon in 1813.

The kingdom of Siam is situated between the Burman empire and the kingdom of Anam, bounded on the north by British India and China. The people are a mixed race of Mongolians, with Chinese and Malayaians; the form of government is despotic. The town of Bankok, the capital of Siam, is the largest in Farther India, its population being reckoned at 100,000.

In the sixteenth century Siam was governed by a Greek of Cephalonia, an influential minister of an enlightened king, who exchanged an embassy with France, but which did not lead to any regular intercourse between the two countries. Britain entered into a commercial treaty with the Siamese in 1826, and the United States of America concluded a treaty with them in 1833. The present sovereign, who assumed power in April 1851, was a Buddhist priest; he is said to be intelligent.

There are about 2000 Roman Catholics, chiefly Portuguese natives. The American Board of Missions had a station at Bankok till 1849. A desire for Christian instruction is said to be general among the Siamese priests and people; but the hopes of the missionaries in regard to them have not been realized. The New Testament has been translated into and printed in the Siamese language.

Anam, or Cochin-China, extends along the coast of the China Sea, to the east of Siam. It comprises Cochin-China in the centre, Tonquin on the north, and Cambodia on the south. The country is very little known; the people are said to comprise numerous races resembling the Chinese. The government is despotic. During the reign of Louis XVI., France entered into a treaty with the Anamese, which was the means of introducing French officers into the army, and Jesuit missionaries, who settled and preached in the country. The latter were in favour for some time, but their vicar-apostolic having been subjected to persecution in 1847, a French ship of war was sent to chastise the Anamese by the destruction of their fleet. The state religion is Buddhism. The Mohammedans are chiefly inhabitants of Cambodia. It is asserted that there is no Cochin-Chinese who has not been at school, and that books are to be met with even in the poorest houses.

J The Malays are everywhere Mohammedans. Slavery is common among them. The London Missionary Society had stations at Malacca, Pulo-Penang, and Singapore; but after the opening of China they were all given up. They had been attended with but little success. There were also American missionaries at Singapore, but they also were removed. Various versions of the Malay Scriptures have been printed.

K AFGHANISTAN.

The population of Afghanistan and Beloochistan is extremely mixed in various tribes; they all profess to be Mohammedans, and are mostly of the Sunnite creed.

L The Kafirs appear to be the aboriginal inhabitants of the country. The name Kafirstan, "Land of Infidelity," has been given by the neighbouring Mussulmans, in consequence of their rejection of Mohammedanism. The Kafirs bear a mortal hatred to the Mussulmans, by whom their country has been often invaded, but never conquered.

M The people of Turkestan are all of the Sunnite sect of Mohammedans, except a small number of Jews, and the natives of the country of Derraset, who are idolaters. Mohammedanism is more strictly followed in Bokhara than in any other country of Asia. The Jews (reckoned 4000 in number) are subjected to many privations.

N PERSIA.

The Persians are Mohammedans of the Sheah sect, rejecting the authority of the three first caliphs, on which, and other accounts, there is a continual feud between them and most other Mussulmans. The population is divided into numerous sects, comprising Sunnite Mohammedans, Armenians, Nestorians, Jews, and Guebres or Parsis. The United Presbyterian Church in Scotland sent, a few years since, Dr Glen and his son to Persia, to circulate an edition of the Old Testament translated by himself into Persian, and of the New Testament translated by Henry Martyn.

O INDIA.

The Indo-British empire has added to its dominions, since 1834, territories and tributary states to the extent of 167,013 square miles, and a population of 8,572,630.

India is not, as is commonly supposed, one country; it is no more one country than Europe is one country. "In reading anything written on India," says the Rev. W. Buyers, "it is always necessary to bear in mind that *India is only a name applied by Europeans to a great many countries* peopled by different nations and races of men as different from each other in language, habits, and customs, as the various nations inhabiting modern Europe." The Bengali, the Hindustani, the Marathi, and the Tamilian, are as much men of different nations as the English, the French, the Germans, or the Italians.[1]

Brahmanism prevails over the whole peninsula, mixed with other forms of Paganism and Mohammedanism. In the Panjaub, which was subjected to British rule in 1849, the inhabitants, amounting to 4,740,000, are Hindoos, and bear an implacable hatred to the Mohammedans. The greater portion of the people of Cashmere are Mohammedans.

The aboriginal races of India have no literature, and almost no traditions. The *Ghonds* in Orissa occupy 70,000 square miles, and are estimated at 2,500,000 souls. Human sacrifices prevailed among them till 1847, when they were abolished by the British Government. On the Eastern Ghauts and in Mysore are the *Chensuars*, a race still more barbarous. Near Madras the *Yenadys* are so rude as not to be able to reckon higher than five. The *Bhils*, in the hill country bordering Mewar, are robbers and outcasts, and have scarce any faith or form of worship. The *Warlis* and *Katodars* occupy the entire mountain range of Western India. The former worship the Lord of Tigers, to whom they sacrifice fowls and goats; they recognise no other god, and have no idea of a future state. The *Katodars* or *Todawars* inhabit the Neilgherries; they live on the outskirts of towns and villages, feeding on snakes, rats, and offal. Nearly allied to these are the *Buddaghars*, and the robber tribe of the *Phansingars*. All the aborigines live in a state of perpetual servitude, and are known by the general name of Coolies. The predecessors of the Brahmins, it is agreed, came from the west of the Indus, B.C. 1100. The Hindoos brought with them into India a language closely connected with those of Europe.[2] They reduced to serfage all they conquered. They introduced an elaborate code of laws, which have survived nearly 3000 years, and flourishes still.

Contemporaneous with Brahmanism came the religion of Buddha, the rival, and for long the dominant faith, of which the cave temples in the Deccan indicate the supremacy, and attest the decadence. It seems to have flourished up to the fifth, and to have declined during the eighth century. The Mohammedan invasion of India began in the eleventh, and was completed in the fifteenth century; but most of the Mohammedans now in India spring from a Brahminical stock. The Arabs or Siddees of Central India and the Concan came in successive hordes from Arabia and Africa. The Parsis, or fire-worshippers, were refugees from the religious persecution of Persia. Though small in numbers, they have earned a distinguished name for public munificence, skill, and success in commerce; and they have led the way in the cause of female education.

The Government of India has for some years past been devoting laudable attention to education. In the different establishments of India, maintained at the public expense, in the years 1849-50, there were 23,170 students. In the north-west provinces, in 1850, there were 1706 students; of whom 62 were Christians, 1364 Hindoos, and 280 Mohammedans. In the coast provinces there were 6163 students; of whom 140 were Christians, 4858 Hindoos, 673 Mohammedans, and 497 of the other sects.

In the Government Vernacular Schools, at the end of 1850, there were 2404 students, whose creeds are not distinguished. At Fort St George, in 1851, there were 180 students; in Bombay, 1850, there were 13,400 pupils, English and vernacular. English is taught in all its schools,[1] and is highly prized by the native youth of India as a mark of education and refinement.

P CEYLON.

The island of Ceylon is inhabited by Singhalese, Moormen, Malabars, and other Hindoos and Malays. The Veddas, or Bedas, the remnants of the aboriginal inhabitants, occupy the interior, subsisting as hunters, on the game and produce of the forests. The religion of the Singhalese is Buddhism.

R The British colonies in the Eastern Straits Settlements, comprise the provinces conquered from Burmah, previous to 1850—Assam, with a population estimated at 602,500; Jynteah, 270,000; Cachar, 70,000; Aracan, 250,000; the coasts of Tenasserim, Martaban, Tavoy, &c., 85,000; and the colonies of Penang, 39,589; Wellesley, 51,509; Malacca, 54,021; and Singapore, 51,421; and in the China Sea, Labuan island and Hong Kong. There are mission stations of the American and English Mission Boards in Assam, Aracan, and in the Tenasserim provinces.

The islands forming the Eastern Archipelago extend along the equator, from the south-east coast of Asia, to the west of Australia. They form five groups:—1. Sumatra, Java, Bali, Lombok, Madura, Banka, Billiton, and the western portion of Borneo. 2. Celebes, Sumbawa, Flores, Timor, Sandalwood Isle, and the

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east part of Borneo. 3. Ceram, Bouro, Gillolo, Timorlaut, Aroo Isles, and Papua. 4. Mindanao, Sooloo, Palawan, and north-east part of Borneo. 5. Luzon, and all that portion of the Philippines stretching from lat. 10° to 19° N.

Two distinct races of men inhabit this region—the Malay, forming the great bulk of the population, especially of the western isles, who are considerably advanced in civilization; and the Papuan, a black race, who are in a rude, savage state, and less susceptible of civilization. Many Chinese emigrants, and a small number of Hindoos, have settled in Borneo and other islands. The Hindoo faith is professed by some of the native tribes, but Mohammedanism, which was introduced at the beginning of the thirteenth century, is the prevailing religion. Christianity has been partially introduced into the European settlements, the principal of which belong to Holland. In 1852 the total population of the Netherlands East Indies, including all subjected to the direct dominion or sovereignty of Holland, was reckoned at 33,600,000, of whom 12,000,000 were in Java alone. Two great varieties of race people the Dutch possessions in the East. 1. The Javanese, with the tribes analogous by their physical constitution and habits—as the Malays, the Dayaks, the aborigines of Borneo, &c. 2. The negrito races—as the Papuans, Timorese, and most of the aborigines of the small south-eastern islands of the Archipelago. The indigenous population is left as much as possible under the direction of its own chiefs. The free exercise of religion is guaranteed by the protection of the Government. Bali is the only island of the Archipelago where the two great forms of the Hindoo religion, the Brahminical (the original) and the Buddhist (the reformed) exist together in harmony. In Lombok the rulers are Hindoos, whilst the subjects are Mohammedan. In Borneo, *Sarawak* has made rapid strides in civilization, under the protection of Sir James Brooke. The town of Sarawak has now an Episcopal church, and a school for Dayak and Chinese children. Borneo, though the largest island in the world, is very scantily inhabited, in consequence of the custom of head-taking required at all the native festivals and ceremonies. The population is supposed not to exceed 2,000,000.

S RUSSIAN ASIA.

Siberia is colonized not only by criminals, but also by vagabonds and serfs considered dangerous to their masters. These are collected at Moscow, from all parts of the empire, and sent off in weekly convoys, to the number of about 10,000 per annum. One-fifth of these die in ten years, from fatigue of the journey and change of climate. Arrived in Siberia, they are divided into three classes:—1st, For forced labour in the mines; 2d, Public labour (to be afterwards established, provisionally, as colonists); 3d, Those destined for immediate colonization. These observe the rites of the Greek Church. Among the aboriginal populations in the west of Siberia, from the northern Urals to the rivers Irtish and Tobol, *Shamanism*, more or less mixed with impure *Christianity*, prevails. Between the Obi and the Yenisei, in the Government of Tobolsk, Shamanism prevails in the north, among the Samoeids, and the imperfect Christianity of the Greek Church in the south, among the Ostiaks. In the eastern portion of Siberia, from the Yenisei to Kamtschatka, and from the Arctic Ocean to the Chinese empire, Buddhism, Paganism, and an imperfect Christianity prevail. The south-west of Siberia, including the governments of Omsk, Tomsk, and part of Irkutsk, falls within the limits of the great Turkish branch of the human family, and the prevalent form of religion is Mohammedanism.

Siberia has a few educational establishments, still in their infancy. In the four governments, Tobolsk, Tomsk, Yeniseisk, and Irkutsk, there are three gymnasia. In 1850, the Emperor decided that in those of Tobolsk and Tomsk, the study of Greek should be replaced by that of the Tartar language, at the option of the student. The Old and New Testaments have been translated into Mongolian by the London Missionary Society.

T OTTOMAN ASIA.

The numbers stated in the Table as pertaining to the Greek Church, comprise all the eastern churches recognising the authority of the Holy See, although differing in ritual. These are—

1. The *Latins or Catholics* following the Romish liturgy; (they have a resident Patriarch at Jerusalem, since 1847), ...
2. The *United Greeks, or Melchites*, having a resident Patriarch at Damascus, and eight suffragan sees, . 25,000
3. The *United Armenians*, whose Patriarch resides at Bezoumma, in Mount Lebanon, with seven archbishops *in partibus*, and for suffragans, the bishops of Aleppo, Mardin and Amasia-Tokat, ... 75,000
4. The *Syrians* and *United Chaldeans*, with patriarchs at Mosul and Aleppo, and fifteen suffragans, . . 20,000

Among the Catholics are included the Maronites, with a Patriarch at Canobin, in Lebanon, and seven suffragan bishops, ... 140,000

In 1853 the population of the city of Jerusalem was reckoned at . . 25,000

Of whom there were—
Mohammedans, . 5,000
Christians, . . 10,000
Jews, . . . 10,000

—besides about 2000 strangers not under Ottoman jurisdiction.

The different races and religions of the entire population of the Ottoman Empire are distributed, geographically, in the following manner:—

RACES AND RELIGIONS.	EUROPE.	ASIA.	AFRICA.	TOTAL.
Mussulmans (Moham.)	3,800,000	12,950,000	3,800,000	20,550,000
Greeks and Armenians	11,370,000	2,360,000	——	13,730,000
Catholics .	260,000	640,000	——	900,000
Jews . . .	70,000	100,000	——	170,000

The Arabs and Koords of Mesopotamia and Assyria are Mohammedans of the Sunnite sect; but there is a Christian population scattered over the whole region. In the vicinity of Mosul and Mardin, the greater number of villages are chiefly peopled with various denominations of Christians. The *Nestorians, Chaldeans*, or *Syrians*, as they are indifferently termed, are divided into two sects—those who have acknowledged the supremacy of the Roman Pontiff, and those who adhere to their ancient faith. The *Jacobites* are also subdivided. Among the *Armenians* and *Nestorians* a great and beneficial change is being produced through the judicious and earnest exertions of the American missionaries, who have translated the Scriptures into the modern Syriac or Nestorian. Very few acknowledge an adherence to the Romish communion.

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[1] BUYERS' *Letters on India*.

[2] Generally speaking, "the whole of India may now be divided between two classes of language—the language of the intruding Arians, or Sanskritoid, in the north, and the language of a civilized race in the south of India, represented by its most cultivated branch, the Tamil."—(See Missionary Map of India.) The whole of Upper India, including the Panjaub, from the Himalayas to the Vindhyan range, but exclusive of Bengal, may be said to be possessed of one language, the Hindi. Bengali is the language of 20,000,000 souls. The Goodwani is marked provisionally as a member of the Tamiloid family; but of the country and its people very little is known.—*The Languages of India*, by SIR ERSKINE PERRY, President, Bombay branch of the Royal Asiatic Society, Trans. 1853.

[1] See Notes on Missionary Map of India.

MISSIONARY MAP OF INDIA.

HINDOSTAN, or India, has an area estimated at 1,309,200 square miles, or nearly twenty-four times that of England and Wales; and a population estimated at 152,609,254—equal to that of a large portion of Europe, and probably equal to one-sixth of the whole human race. With the exception of China, it is the most densely peopled country in the world. Of the inhabitants of this vast country, it is supposed that 105,000,000 are natives—the foreigners being partly Asiatics and partly Europeans. Among these are reckoned 10,000,000 Arabs and Persians, 1,000,000 descendants of early Portuguese settlers, mostly on the west coast, and 80,000 Europeans, chiefly British.[1] The Hindoo population is divided into four classes or castes—namely, *Brahmans*; *Shatryas*, or military; *Vaisyas*, or agriculturists, merchants, and herdsmen; and *Sudras*, artisans or servants.

Brahmanism, the national faith of India, is the form of superstition which, for more than 3000 years, has counted as its votaries the vast majority of the people.

India was occupied as a Mission field in the following order: In the sixteenth century the Portuguese introduced the Roman Catholic religion into India. In the seventeenth century the Dutch made some attempts to introduce the Reformed religion on the coast of Coromandel, but with no great success. In 1705 the Danish Government sent two missionaries to Tranquebar; and other stations were subsequently occupied at Madras, Cuddalore, Trichinopoly, Tanjore, and Calcutta. In 1793 the Baptist Missionary Society sent out to Bengal its first missionaries, Carey and Thomas; in 1804 the London Missionary Society; in 1814 the Church Missionary Society; in 1817 the Methodist Missionary Society; in 1821 the General Baptist Missionary Society; in 1822 the Scottish Missionary Society; in 1829 the General Assembly of the Church of Scotland (since 1843 the General Assembly of the Free Church); in 1840 the General Assembly of the Presbyterian Church in Ireland; in 1812 the American Board for Foreign Missions; in 1833 the American Presbyterian Board of Foreign Missions; in 1834 the German Missionary Society. To these must be added the Society for the Propagation of the Gospel in Foreign Parts, the Welsh Foreign Missionary Society, the Rhenish Missionary Society, Gossners Missionary Society, and several other missionary bodies on the Continent of Europe.

At the close of 1850, after half a century of steady progress, the twenty-two Missionary Societies had established 260 stations, at which the Gospel is preached by 403 missionaries, of whom 22 are ordained natives; assisted by 551 native catechists. They have founded 309 native churches, having 7,356 members; who form the nucleus of a native church community comprising 103,000 individuals, who regularly enjoy Bible instruction. These are distributed among the different stations according to the subjoined Table I.:— .

[Continued at the foot of next page, "AFRICA."

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[1] In 1852 the number of European residents in the three Presidencies, not in the service of the Queen or the East India Company, was 10,000; and the total number of residents in India from the British Isles is reckoned at 75,000, including the military.

A F R I C A.

AREA, 2,370 SQUARE DEGREES, or 11,376,000 SQUARE MILES. POPULATION, 60,000,000?

	POLITICAL RELATIONS.					RELIGIOUS DISTINCTIONS.					
	STATE.	TITLE.	SQUARE MILES.	POPULATION.	DATE OF ESTIMATE.	PROTESTANT.	ROMAN CATHOLIC.	GREEK CHURCH.	JEWS.	MOHAMMEDAN.	PAGAN.
NORTHERN.	MAROCCO, . . . **A**	Empire,	220,000	8,500,000		200	100		340,000	8,039,700	120,000
	ALGERIA, . . . **B**	Regency,		2,561,003	1853	2,561	121,226		614	100,000?	100,833?
	TUNIS, TRIPOLI, and FEZ, . . . **C**	Pashaliks,	268,000	1,800,000		500	1,000		32,000	1,769,500	
	EGYPT, . . . **D**	Viceroyalty,	38,000	2,895,500	1850	1,000	13,500?	15,000?	7,000	2,834,000	25,000
	NUBIA and KORDOFAN, **E**	„	300,000	4,000,000?	1850					1,000,000?	3,000,000?
CENTRAL.	DAR SELAH, BELUD-EL-JERID, TIBOO, SAHARA, and other Deserts; the Oases—BOURNOU, HOUSSA, DARFUR, &c., **F**	Chiefships and Princedoms,	220,000?	10,000,000?	1850					3,000,000?	7,000,000?
EASTERN.	ABYSSINIA, with TIGRE, SHOA, SEMEN, AMHARA, KAFFA, ADEL, AJAN, &c., . . . **G**	Princedoms and Chiefships,	400,000?	6,000,000?	1850				50,000?	2,000,000?	3,000,000?
	POSSESSIONS of the IMAUM of MUSCAT, . . **H**		560,000?	10,000,000?						2,000,000?	8,000,000?
	MOZAMBIQUE and its DEPENDENCIES (Portuguese) **I**			280,610	1841		30,000?				250,610
	ISLANDS of MADAGASCAR, COMORO, SOCOTRA, &c., . . . **J**	Princedoms,	250,000?	4,000,000?							
WESTERN.	SENEGAMBIA and UPPER GUINEA, GOLD COAST, SLAVE COAST, and part of LOWER GUINEA, (CALABAR, BIAFRA, LOANGO, &c.) . **K-L**	Princedoms and Chiefships,	500,000	8,000,000?					See	Notes K	to M.
	LIBERIA, . . . **M**	Republic,		80,000?							
	ANGOLA, BENGUELA, and DEPENDENCIES, . .			400,000	1841						
SOUTHERN.	CAPE COLONY, including BRITISH KAFFRARIA, **N**	Colony,	118,256	285,279	1849				See	Note	N.
	NATAL, . . . **O**	„	16,000	100,000							

REMARKS.

A THE population of Marocco comprises three distinct nations—the Berbers, Arabs, and Moors. The first are the true aborigines; they have hereditary chiefs, and are only nominally under the authority of the emperor. The different nations and tribes comprise—

Berbers and Shellocks,	3,750,000
Moors,	3,550,000
Bedouin Arabs,	740,000
Negroes,	120,000
Jews,	340,000
Christians,	300
Renegades,	200

The only recognised and protected religion is the Mohammedan. The emperor is spiritual as well as temporal chief. Jews are barely tolerated, being subjected to heavy exactions and severe restrictions. In the schools attached to the mosques, children are taught to read verses of the Koran, which, when committed to memory, are copied out as an exercise in writing. On leaving school, the pupil enters the Lyceum, and lastly the University of Fezzan, called the "House of Science," which, though now decayed, enjoyed a high reputation in the middle ages.

B By the census of 1851 the population of the French territory of Algiers comprised 2,429,720 natives, and 131,283 Europeans. In 1853, the Europeans, including the military, amounted to 135,000. The civil population is thus distinguished—French, 69,930; Spanish, 35,129; Italians, 7408; Anglo-Maltese, 3609; Germans, 3025; Swiss, 1223; various, 1927. According to religion—Protestants, 2561; Roman Catholics, 121,226; Jews (European), 614. In 1852 there were 3 native colleges, and 593 higher, and 851 primary schools for native boys. Since 1846 the Arab tribes have built 3752 storehouses, constructed roads, bridges, mills, &c., and planted one million fruit-trees.

C Tunis and Tripoli, with Fez, form nominally part of the Ottoman empire in Africa. The state religion is Mohammedanism. The city of Tunis is supposed to contain 30,000 Jews, and Tripoli 1,500 Christians, and 2,000 Jews.

The people of Barca are Bedouin Arabs, Mohammedans, with a few Jews in the towns.

D The population of Egypt is estimated, from an official return of the number of houses, to comprise—

Egyptian Mussulmans,	2,600,000
Christian Copts,	150,000
Osmanli Turks,	12,000
Bedouin Arabs,	70,000
Barbaras or Berbers,	5,000
Negroes,	20,000
Abyssinians,	5,000
Circassian and Georgian Slaves,	5,000
Jews,	7,000
Syrians,	5,000
Armenians,	2,000
Greeks,	5,000
Europeans domiciled in Egypt, about	9,500

—comprising, Italians, 2,000; Maltese, 1,000; French 6,000; English, 200; Austrians, 200; Russians and Poles, 50; Spaniards, 20; Swiss, Belgians, Dutch, Prussians, Swedes, and Danes, about 100.

The Coptic is the church of the Egyptian Christians, descendants of the ancient inhabitants of the country, and of the Greeks and Romans who occupied it till the time of the Ptolemies. Their creed is based very imperfectly on the Bible, and on the ancient church. It is very corrupt and superstitious. Their history is a long record of persecution and suffering at the hands of the Mohammedans. Ten thousand of their number reside at Cairo. They form the chief part of the village population in Upper Egypt, and are numerous in the district of the Fayoum. The Copts in connection with Rome are estimated at 5,000. A portion are adherents of the Greek or Syriac Church; some have embraced Mohammedanism of the Fellah type; and there are a small number of Jacobites in the Saïd. The Jews are chiefly of the Caraite sect, who reject the Talmud and its commentators. The Europeans resident in Egypt have a Roman Catholic church, under the protection of France.

E The Nubians claim their origin from the ancient Egyptians. Previous to the conquest of the country by Ibrahim Pasha, in 1821, it was governed by numerous petty chiefs. Since then it has been under the dominion of Egypt.

Kordofan is peopled by three races—the Nubas or Negroes, the true indigenes; the Dongolani, who at different times invaded the country; and tribes of Bedouin Arabs from the Hedjaz. Several of the tribes are Mohammedans, the others are Pagans.

F The Great Desert of Sahara is now known not to be, as formerly supposed, an ocean of sand, but rather a rocky wilderness, with sufficient vegetation to support the camel. It contains numerous oases and habitable spots, and is traversed in many directions by caravan routes. The portions of this vast region best known are the Algerian Sahara (the Belud-el-Jerid, or Country of Dates), the six Wadys of which have been recently explored,[1] and appear to be inhabited by intelligent and industrious tribes; the Oasis of Gadamis, on the south-west; and that of Fezzan, on the south of Tripoli—the latter inhabited by Arabs, Moors, and Negroes. Among the nomade tribes who dispute the empire of the Desert, are the Tuaricks, who occupy the central portion of the Sahara.[2] They are Mohammedans, and very superstitious; and the Tiboos on the east, mostly Mohammedans and Pagans.

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[1] See Bullet. de la Société de Géographie, 1852, p. 326.
[2] Journal, Geographical Society, vol. xxi. p. 166.

The southern border of the Desert, about lat. 16° N., forms the northern boundary of the region occupied by the true Negro race—the southern limit being (on the west, at least) the Equator; in the interior it is unknown. The western limit is the Atlantic Ocean, and the eastern, Kordofan. The numerous tribes inhabiting this region, which includes the greater portion of Soudan, are pagans, except on the northern and eastern limits, where they are partly Mohammedans. In Timbuctoo and Bornoo the people are zealous followers of the False Prophet. The prevailing form of Pagan superstition is Fetichism, which is here exhibited in its most revolting forms.

Darfur is under Mussulman domination. The people do not possess written documents.

G Christianity became the national religion of Abyssinia in A.D. 330; the church is a branch of the Coptic, having in its ritual a great admixture of Mohammedan and Pagan rites and Jewish ceremonies. For more than half a century it has been divided by rancorous controversies. The Copts are ignorant, degraded, and superstitious; yet the little of Christianity they have preserved raises them, in many respects, above the other nations of Africa. The Jews in early times found a safe asylum among the mountains of Abyssinia, where they still exist, a separate and peculiar people. The Jewish Sabbath is strictly observed throughout the country.[1]

Major Harris estimates the population of Shoa at 2,500,000; of whom 1,000,000 are Coptic Christians, and 1,500,000 Gallas and Mohammedans.

H The Imaum of Muscat holds real or assumed possession of all the country from Cape Guardafui to Cape Delgado, including the islands of Socotra, Zanzibar, and Monfeea. Many of the inhabitants profess Mohammedanism.

I From Cape Delgado, south to Cape Delagoa, including Mozambique and Sofala, the country is under the nominal dominion of the Portuguese, whose power once extended over a great part of Eastern Africa, but which is now rapidly on the decline. The population is estimated by Portuguese authorities at 280,610, composed of European Portuguese, and planters descended from the old settlers, about 1,500 families; the rest being free negroes and native soldiers.

J MADAGASCAR.

In 1825 the London Missionary Society had 2,000 pupils among the Ovahs; but since then the native Christians have suffered severe persecutions.

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[1] Wilson's Lands of the Bible; Univers Pittoresque; Harris's Highlands of Ethiopia.

K WESTERN AFRICA.

Western Africa, formerly known chiefly as the great seat of the slave trade, and the scene of every atrocity, has within the last twenty years made rapid progress in civilisation. The slave trade has been all but extirpated over an extent of 2,500 miles of coast, from Senegambia to the south of the Equator; and a country containing, on a moderate computation, twenty millions of human beings, has thus been opened to the benefits of a legitimate commerce, and the blessings of a religious education. There are now nine British, seven French, two Dutch, and two American stations on the coast. These are resorted to by the natives of the interior for the exchange of their products; and so rapid has been the growth of commerce, that while, previous to the suppression of the slave trade, it was limited to ivory and gold dust, to the estimated annual amount of £20,000, the exports in 1851 were calculated at £200,000, consisting chiefly of palm oil. Previous to 1832 there were no mission stations between Sierra Leone and the Cape of Good Hope; now, there have been founded twelve independent missions along the coast, and some far in the interior. Among them are the interesting station of the Wesleyans at Coomassie, the capital of Ashantee, the flourishing one of the Church Missionary Society of Abbeokuta, and another at Badagry. At these stations the Gospel is regularly preached; and upwards of 10,000 African youth are under Christian instruction. Different languages have been studied and reduced to system; and presses are employed in printing books for those already taught to read.

The negro races of this region consist chiefly of the tribes of Joloffs and Mandingoes, Pagans and Fetichists, with an admixture of Arabs and other Mohammedans. The population of the British colony of Gambia was, in 1848, 4,851. The Wesleyan body have mission stations at Bathurst, Barra, and in MacCarthy island, the schools of which were attended by 600 pupils. The population of the British colony of Sierra Leone, in 1850, was chiefly composed of slaves recaptured by the British squadron. It comprised—

RACES.

Europeans,	111
Maroons,	15
Nova Scotians,	49
Liberated Africans,	20,243
Native Creoles,	20,766
West Indians,	91
Americans,	121
Kroomen,	560
Native strangers,	3,516
	45,472

CREEDS.

Episcopalians,	16,605
Presbyterians,	7
Wesleyan Methodists,	4,884
Baptists,	508
Lady Huntingdon's Connection,	1,552
Roman Catholics,	56
Jews,	6
Mohammedans,	1,778
Pagans,	7,230

—*Parliamentary Paper.*

The valuable report from which the above is extracted, contains an interesting list of the tribes and localities to which the liberated Africans, who have found shelter in the colony, originally belonged. These comprise 100 tribes; and the vast extent of country over which the slave trade has extended is shown by the fact, that there are natives of nearly the whole of the Negro territory, from the borders of the Sahara on the north, to Lake Tchad on the east, the countries of Upper and Lower Guinea, and the regions of Mozambique and Sofala.

The colony is well supplied with schools, but the system of education appears to be ill-adapted to the wants of the population. In 1850 there were 58 schools, attended by 6,795 scholars.

L The population of the British colony of the Gold Coast was, in 1850, estimated at 288,500, no census having ever been made; but the addition, in 1850, of the territory formerly under the Danish flag, has greatly increased the amount of population claiming British protection. The native population of this district is mostly of the Fanti and Whidah tribes, Fetichists. Their number formerly, under the Danish rule, was estimated at 100,000. The latest returns show some gratifying results of the civilising influence of good government and religious training, in the docility and peaceful conduct of the natives. The schools of the Government and of the Wesleyan Methodists turn out from 80 to 100 young people annually, who are imbued with, at least, the principles of a Christian education. The cession of the Danish territory has greatly facilitated the suppression of the slave trade along the coast.

The possessions of the Netherlands government on the Gold Coast extend between 4° 40' and 5° 40' N., and long. 0° 10' and 2° 16' west Greenwich. Near the middle of this space, on the coast, is St George d'Elmina, the seat of administration, with a garrison and a governor. The area of the whole territory is estimated at 10,625 square miles, and the population at 100,000, including Europeans, who are mostly Protestants.

The French colony of Senegal, with the islands of St Louis and Goree, had, in 1841, a population of 19,676, of whom 10,283 were slaves.

Portugal has, in the Cape Verde islands, a population of 80,000; and in Bissao and Casamance, on the Guinea coast, about 10,000. The Portuguese possessions extend from Cape St Mary to Cape Tagrin, about the mouths of the Rio Casamance. The natives are Mandingoes, and are Mohammedans.

M The interesting settlement of Liberia—commenced by the American Colonisation Society, in 1823—extends, including the Maryland colonisation colony of Cape Palmas, above 500 miles along the coast, with a breadth of about forty miles. Its population, consisting of emancipated slaves, free blacks, and coloured people from the United States, with Africans rescued from slave traders, amounted, in 1843, to 6,343; but the native population who seek the protection of its Government is reckoned at more than 200,000. It is governed by a Negro president, and was recognised as an independent republic in 1848. Liberia had in 1843, sixteen schools, with 562 scholars; and twenty-three places of worship, with 1,474 communicants. Its commerce is increasing; and in every point of view its establishment must be considered a most successful experiment for the colonisation of Western Africa.

South of the Equator, to Cape Negro, extending to an unknown distance in the interior, the native races are Kaffirs. The prevailing form of superstition is Fetichism, but in Loango, as on all the Guinea coast, the natives practise circumcision. This extensive country, under the designation of the kingdoms of Angola and Benguela, and its dependencies, with a population estimated at 400,000, divided into three classes—Europeans, indigenes, and a mixed class—is claimed by Portugal, having been discovered and colonised by the Portuguese, in the fifteenth century. They have a few settlements on the coasts, but their rule extends little, if at all, into the interior—Benguela being inhabited by small, independent nations—vassals, allies, or enemies of the Portuguese. "The colonists live in a state of the grossest immorality, and devote all their energies to the trade in slaves."[1] Between the years 1843 and 1847 the trade in slaves increased enormously on this coast. Since that time it has been greatly suppressed.[2]

N CAPE COLONY.

By the census of 1849, the white population of the Cape Colony amounts to 76,490; and the coloured population is estimated at 208,789.

Strictly speaking, there is no established church in this colony, but provision is annually made, by vote of the legislative council, for support of the ministers of the Dutch Reformed Church, and the bishop and chaplains of the English Episcopalian Church; and grants are voted in support of the Scottish and Lutheran Churches in Cape Town, the Wesleyan Church at Salem, Albany, and the Roman Catholic Church in Cape Town and Graham's Town. From the returns of 1846, the numbers belonging to the different denominations were—

	White.	Coloured.	Total.
English Episcopalian,	7,543	587	8,130
Dutch Reformed,	51,848	6,738	58,586
Other Presbyterians,	745	3,720	4,465
Roman Catholic,	3,500	150	3,650
Wesleyan,	4,275	6,745	11,020
Independent,	1,202	11,803	13,005
Moravian,	31	6,191	6,222
Lutheran,	1,166	5,814	6,980
	70,310	41,748	112,058

In 1849 Cape Town had a population of 23,749; some years previously it was estimated to contain 14,767 Christians, 6435 Mohammedans, 170 Jews, 641 heathens—two-thirds being professedly Christian, and one-third Mohammedan.

The present improved system of education was settled by a Government minute of 1839, according to which, each chief town of the several divisions has a first class, or principal school, while second class, or elementary schools, are provided for the mission stations, and at certain localities among the agricultural districts. At each of these schools, religious instruction, (restricted to a knowledge of the Bible,) and a grammatical knowledge of the English language (communicated through the medium of the Dutch, where that is the vernacular tongue,) are imperative. The system was recommended by Sir John Herschel; and a body of teachers, selected chiefly from the Scotch universities, was sent out in 1840 and 1841 at the public expense. Their labours have been highly beneficial to the colony.

In 1847, the number of schools on the establishment was 86, at which 9,080 pupils were enrolled.

O NATAL.

The colony of Natal has an area of about 18,000 square miles. The vast majority of its population, estimated in 1850 to amount to at least 100,000, are uncivilised natives, chiefly refugees from, or remnants of, tribes conquered by the Zoolah nation. The docility of the natives, and their willingness to receive instruction, render this an encouraging field for missionary enterprise. Already Mission stations are in operation under the Wesleyans, and under the American Board.

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[1] Tams. W. Africa, 1845.
[2] Parl. Papers, 1851.

MISSIONARY MAP OF SOUTH AFRICA.

In 1736 George Schmidt, one of the United Brethren, proceeded to South Africa, with the view of Christianising the Hottentots. He began at a place called Bavian's Kloof, about 130 miles from Cape Town; but having returned to Europe in a few years, the mission was suspended. It was resumed in 1792 by M. Vander Kemp, of the Dutch Missionary Society of Rotterdam. In 1798 the London Missionary Society, in 1815 the Methodist Missionary Society, in 1821 the Glasgow Missionary Society, in 1829 the Paris Missionary Society and the Rhenish Missionary Society, in 1833 the Berlin Missionary Society, and in 1834 the American Board of Foreign Missions, commenced sending missions to South Africa. By these various societies numerous missionary stations were formed, both within and beyond the colony of the Cape of Good Hope, amongst a great variety of tribes—Hottentots, Bushmen, Namaquas, Damaras, Corranas, Griquas, Bechuanas, Fingoes, Kafirs, and Zooblahs. The stations originally established by the Glasgow Missionary Society were of late years transferred, partly to the General Assembly of the Free Church, and partly to the United Presbyterian Board of Missions. Of missions so varied it is difficult to estimate the results; but on the whole their success has been considerable, especially those of the French missionaries. The principal stations are marked on the Map.

MISSIONARY MAP OF INDIA—*Continued from preceding page, "ASIA."*

The training of the young occupies an important place in the labours of the missionaries. In the majority of schools, education consists in reading, writing, and the elements of general knowledge; but in some cases it is of a very superior kind. In each of them the Bible is taught. In all, 113,000 children are under instruction.

There are 1,345 day-schools, in which 83,700 boys receive instruction in their own vernacular tongue; 73 boarding-schools, in which 1,992 boys, mostly Christian, are trained under the missionaries, on whose premises they reside; and 128 day-schools, in which 14,000 boys receive a sound scriptural education in the English language.

For the training of females there are 354 day-schools, with 11,500 girls; and 91 boarding-schools, with 2,450 girls, taught in the vernacular languages. These schools are distributed throughout India according to the subjoined Table II.

I.—Distribution of Missionaries, Native Preachers, &c.

DISTRICTS.	Mission Stations.	Missionaries.	Native Preachers.	Native Churches.	Members.	Christians.
Bengal, Orissa, and Assam,	69	101	125	71	3,416	14,401
North-West Provinces,	24	58	39	21	608	1,828
Madras Presidency,	113	164	308	162	10,464	74,512
Bombay Presidency,	19	37	11	12	223	554
Ceylon,	55	43	58	43	2,645	11,859
	280	403	541	309	17,356	103,155

II.—Distribution of Schools.

DISTRICTS.	Vernacular Day Schools.		Boarding Schools.		English Schools.		Day Schools.		Boarding Schools.	
	Schools.	Boys.	Schools.	Boys.	Schools.	Boys.	Schools.	Girls.	Schools.	Girls.
Bengal, Orissa, and Assam,	127	6,369	21	761	22	6,614	26	690	23	836
North-West Provinces,	55	3,078	10	209	16	1,297	8	213	11	208
Madras Presidency,	852	61,366	32	754	44	4,156	222	6,929	41	1,101
Bombay Presidency,	65	3,648	4	64	9	934	28	1,067	6	129
Ceylon,	246	9,126	6	204	37	1,675	70	2,630	8	172
	1,345	83,787	73	1,992	128	14,676	354	11,549	91	2,446

There are in India eight Bible and fifteen Tract Societies, auxiliary to those of England and America. The whole Bible has been translated into ten languages, and the New Testament into five others;[1] and in other languages tracts have been written for distribution among the Hindoo and Mussulman population.[2]

During 1851 they published 130,000 copies of the Bible, or selections from it, in thirteen languages, of which they distributed 185,400 copies. For the production of these, the missionaries maintain twenty-five printing establishments. They also conduct several English periodicals. The cost of all these missionary operations amounted, in 1850, to £187,000; of which sum, £153,460 were supplied by Europe and America, and £33,540 were contributed by Europeans in India.

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[1] Besides the Serampore versions, which consisted of thirty-nine translations of the whole or parts of the Bible into the Indian tongues.

[2] See the *Results of Missionary Labour in India.* 8vo. London, 1852. Reprinted from the *Calcutta Review*, Oct. 1851. Since the above results were published, the Rev. Mr Mullens has been employed by the Calcutta Missionary Conference to correct the missionary statistics to the present time. This has been accomplished, it is said, "by means of extensive correspondence with the missionaries at the different stations, and the following is an abstract of the results. In 1852, the twenty-two missionary societies had, in India and Ceylon, 443 missionaries (of whom 48 are ordained natives), and 698 native catechists, resident at 313 stations. They had founded 331 native churches, containing 18,410 communicants, in a community of 112,191 native Christians. They maintain 1,347 vernacular day-schools, with 47,504 boys; and 93 boarding-schools, with 2,414 Christian boys. They superintend 126 superior English day-schools, and instruct in these 14,562 boys and young men. Female education, at the same period, comprised 347 day-schools, with 11,519 girls; and 102 boarding-schools, containing 2,779 Christian girls. 71 services are maintained for the benefit of Europeans."—Such is the statement, but it is to be feared that it gives much too favourable an estimate of the progress of Christianity in India.

ON THE

GEOGRAPHICAL DISTRIBUTION OF HEALTH AND DISEASE,

IN CONNEXION CHIEFLY WITH NATURAL PHENOMENA.

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As a sequel to the foregoing essays on the distribution of man according to races, civilisation, and religious belief, the following notes, in explanation of the Map, are devoted to a consideration of the extent to which the human family is affected in the enjoyment of health and the preservation of life, by physical or natural causes. The safest guide in such a field of inquiry is statistics, or the accumulated stores of carefully observed and accurately recorded facts, regarding the occurrence of disease in its different forms, its extension or limitation in space, and the periodicity of its recurrence. But reliable tables of sickness and mortality do not exist, except for very limited and widely-separated portions of the globe. In the absence of positive data, however, a knowledge of the physical conformation of the earth's surface, and the meteorological agencies to which it is exposed, affords, through comparisons of well-known phenomena in long-settled countries, a means of arriving at certain probable conclusions regarding others of which little or nothing is known.

Such general deductions, unsatisfactory though they may be considered as regards present information, are nevertheless valuable as the pioneers of science, affording hints and suggestions for the guidance of the future observer. The subject presents a vast field for investigation, and claims the earnest efforts of every one interested in the progress of society. This consideration, together with a hope that many who contemplate a residence abroad may thus become familiarised with the morbid forms of other lands, must be my apology for this first attempt to represent, in a popular form, the present state of our knowledge on the distribution of health and disease.

The object of medical geography is to ascertain the laws by which disease is distributed, or the manner in which certain conditions inimical to the health of the human frame are found to prevail in certain regions or localities. These laws depend for their elucidation on the facts of PHYSICAL GEOGRAPHY, embracing geographical position, the nature and elevation of the soil, the amount of moisture, temperature, absolute and seasonal, the direction and force of the winds, and the phenomena of electricity.

We have seen (*Physical Atlas*, p. 79) that in the animal and vegetable kingdoms certain plants and animals are, by natural laws, restricted in their range, within a horizontal and a perpendicular direction, to certain localities, beyond which they cannot pass with impunity; and in like manner we find that certain classes of disease seldom extend beyond their usual limits, as ascertained by observation, and that they exist and perpetuate themselves only under certain conditions.

The surface of the globe presents, with the utmost diversity of climate and soil, the greatest unity in its pathology. The same morbid appearances are reproduced with the utmost constancy and regularity in a thousand places at once, wherever the same causes of insalubrity are met with, only they are more intense, continuous, and prolonged in some places than in others.

Similarity of geological formation indicates a similarity in the diseases of a country as seen in the localities visited by malarial fevers. A certain amount of heat, and a sufficient time for its manifestation, is necessary for the development of certain maladies. In the West Indies, the period of disease follows the course of the sun, the unhealthy season occurring at opposite times on the northern and southern sides of the equator. As the sun proceeds northwards in the ecliptic, so the sickly season advances from the southern to the northern islands. In the Mediterranean the mortality is doubled in the hot season, between July and October; and in the southern States of North America the posts of the army are regularly abandoned as the hot or sickly season approaches. But in temperate regions the order is reversed. Throughout Europe generally the maximum mortality occurs at the end of winter, and the minimum in the middle of summer. The Registrar-General of England calculates that a fall of the mean temperature of the air from 45° to 4° or 5° below the freezing-point, destroys from 300 to 500 of the population of London. The agency of the wind is manifested in the distribution of heat and moisture, and in the comparative density of the air, as well as by its direct influence as a distributor of malarial poison; and the absence of wind was uniformly noted as a concomitant of cholera, which in Britain was always most virulent when the calm was greatest, and began to abate when the wind rose. During the great epidemics of Andalusia, 1809-19, the Levanter, a south and south-east wind, was observed to blow constantly for nine months in the year. During the prevalence of the Sirocco, on the Mediterranean shores of Asia and Africa, vaccination fails, as does also inoculation, with small-pox, and ulcers and wounds are more difficult of cure.

As elevation above the surface causes a corresponding reduction in the temperature and in the pressure of the atmosphere, so those diseases which are prevalent at the level of the sea, in cold or temperate countries, are found to be represented by the same, or similar ones, at elevated points in tropical regions, where a corresponding low temperature prevails.

In tropical climates, especially, electricity in its different forms is believed to have a powerful influence on the morbid affections of the human frame; and during the cholera epidemic in Britain, the observations at Greenwich show that the atmosphere was always deficient in positive electricity when the disease was present.[1]

Besides the indirect effects of electricity, the number of deaths caused by lightning is much greater than is generally believed. M. Arago shows, by a return published in 1852, that the average number of deaths in France from this cause amounts to about 70 per annum: and M. Boudin, in a memoir read before the Academy of Sciences in 1854,[2] proves that in the period between 1835 and 1852, no fewer than 1308 persons were killed, and probably three times that number injured, by lightning in France. He affirms that in 1835 the number killed was 111, and in 1847, 108. From the interesting researches of M. Poey of Havana,[3] it appears that, in the United States of America, in a period of twelve years (1842 to 1854) 692 strokes of lightning occurred in the forty-six hottest months; of these 272 were fatal, and 430 not fatal strokes: by the former, 261 persons—men, women, and children—perished, besides 125 animals of different kinds.[4] Official documents, which, however, are admitted to be very imperfect, and probably much below the actual numbers, give for other countries the following annual rates of mortality from lightning: Belgium, 3; Sweden, 9.64; England, 22; Island of Cuba, 0.74. It appears that fatal strokes of lightning are very rare in California, the first on record having occurred on Oct. 10, 1854. The floods occasioned by heavy falls of rain in tropical countries often cause great loss of life; and the hailstorms of India (see p. 66) are frequently fatal to the natives. During a frightful hailstorm near Peshawur on May 15, 1853, 3000 cattle and 80 persons were destroyed. For the destructive effects of storms, see *Physical Atlas*, pp. 62, 63.

REGIONS OF DISEASE CORRESPONDING WITH SEASONS AND ZONES OF CLIMATE.

THAT part of the earth in which any particular form of disease occurs, to the exclusion or limitation of others, may be termed its district of distribution; and such district frequently has not only a horizontal, but also a perpendicular direction. The different seasons of the year, by imprinting an essential character on disease, permit a natural and practical division, which has always been recognised in treating of its distribution: thus the ancients associated the *nervous type* with spring, the *bilious* with summer, the *bilious putrid* with autumn, and the *catarrhal putrid* with winter.

On the same principle the surface of the globe may be divided into belts or zones, distinguished by great leading characteristics, as A, the torrid zone, or belt of greatest annual mean temperature, characterised by the class of diseases which includes *dysentery*, *yellow fever*, *diarrhœa*, *malarial fevers*, and affections of the *liver*, corresponding with the bilious and bilious-putrid, or summer and autumnal type of the seasons, coloured *brown* on the map; B, the sub-torrid and temperate zone, of which inflammatory diseases, represented by *typhoid* fevers, are the characteristic maladies, corresponding with the nervous or spring type of the seasons, coloured *green* on the map; and C, the sub-temperate, sub-arctic, and arctic zone, characterised by *catarrhs* and *colds*, corresponding with the catarrhal-putrid, or winter type of the seasons, coloured *blue* on the map.

I. The immediate dependence of the first class of disease on heat and moisture, as important exciting causes, is shown by the circumstance that its maximum intensity corresponds with the countries situated under the line of greatest annual mean temperature, the assumed equator of heat of the globe (82° Fahr.); which line also intersects the region of greatest aqueous deposition (see "Map of the Distribution of Rain," Pl. 20, p. 65). From this line, to about latitude 23° north, 53 per cent of the deaths are attributable to this class of diseases; while in latitude 35° north, marked nearly by the line of 77° Fahr. in July, and on the boundary of the second zone, the amount is only 14 per cent; and at the Cape of Good Hope, latitude 33° south, it is only 3 per cent. As far as can be ascertained, the mortality from the entire class within this zone amounts to 75 per cent,—the first and second causing 53, and the third 18 per cent of the whole. The same law of decrease with the lowering of temperature is apparent in the seasons of their occurrence. In a series of dysentery epidemics, narrated by Ozanam,[5] 36 occurred at the end of summer, 12 in autumn, and only 1 in winter. Of 13,900 individuals seized with dysentery in Bengal, 7000 were attacked in the warm and humid season, 4500 during the hot and dry season, and 2400 during the cold season. In spring these diseases are more inflammatory in their character, and in autumn more putrid.

The northern limit of this class of diseases is probably the Bermudas, latitude 32° north, in the Atlantic: and California, latitude 38° on the Pacific Ocean, in America. In Asia it extends to near Pekin, latitude 40° north; and in Europe to the south of Spain. Its southern limits are—in America, Buenos Ayres, latitude 34° south, on the Atlantic, where, however, it is not severe; and Lima, latitude 12° south, on the Pacific. In Asia the southern limit includes Aracan, Ava, and Ceylon, Borneo, and the other islands of the Asiatic Archipelago, and thence it extends to the northern shores of Australia. In Africa it includes the island of Madagascar. Within these limits the principal centres of these diseases are, in America, the shores of the Gulf of Mexico, the West India Islands, and the northern portion of South America.[6] In Asia—India,[7] China, Borneo, Ceylon. In Africa—the countries around the Gulf of Guinea on the west, Madagascar and Mozambique on the east, Algeria and the shores and islands of the Mediterranean on the north.[8] Little is known of the perpendicular distribution of these diseases, except that in Mexico they are prevalent at an elevation of 7000 or 8000 feet; and in south-eastern Asia they cease at an elevation of 6000 or 7000 feet above the sea.

II. INFLAMMATORY REGION.—In this zone typhus fever, in its varied forms of gastric, bilious, enteric, &c., fever, takes the place of the yellow and malarial fevers of the torrid zone, and in consequence of fewer of the population being cut off with these, more fall victims to inflammatory affections, of which consumption is the type. But that this latter form of disease is not peculiar to this region, or rather that it becomes more fatal as we approach the tropics, is proved by the fact that in England consumption is only fatal to 3.8 out of every thousand living, while Boston (U.S.) loses 4.0, Baltimore 4.1, Philadelphia 4.2, New York 4.9, and New Orleans 5.6 out of every thousand living.

In North America and Europe, the southern boundary of this group of diseases coincides generally with the northern boundary of the first class. In South America it probably includes Patagonia. In Africa it includes the Cape Colony; and it embraces the south of Australia, Tasmania, and New Zealand. In Asia it is uncertain how far it extends to the eastward. Its northern limit in America includes part of Nova Scotia and Newfoundland; and in Europe the northern boundary includes the British Islands, Norway, and Sweden, to latitude 60° north, whence it appears to follow a south-eastern direction, corresponding nearly with the annual isotherm of 41°, till it gradually declines towards the borders of Asiatic Russia. These, however, are only to be considered as preliminary indications, to be rectified by the acquisition of more exact information.

III. The boundaries of this group of diseases, which, as we have seen, is characterised by catarrhs, include the whole of Europe to the north of the preceding class. In America it extends south to Boston and New York, including the district of the Canadian Lakes. Thence it continues north-west nearly on the line of 41° annual temperature. Although very little is known of the diseases of Central Asia, yet, when we consider the elevation of the surface, the vegetation and the conditions of climate, we may assume that this class of diseases extends there to about latitude 45°. Iceland is the best-known locality of this zone, and may therefore be taken as its representative. The island is visited by catarrh every year in spring or in early summer. It is also visited at short intervals by catarrhal fevers,—a true influenza, which usually has a great effect on the mortality. When these epidemics appear, they attack at once the entire population, and spread in an incredibly short time over the whole island.[9] Pallas says that the majority of Icelanders die, before the age of fifty, from asthmatic or catarrhal affections of the lungs; and Crantz[10] affirms that catarrh is a very prevalent disease in Greenland. Catarrh is also common in Labrador. At Okhotsk in Siberia it is accompanied with difficulty of breathing; and a cough, called "Ho," is endemic among the Samoeids.

SKETCH OF THE CLIMATOLOGY AND DISEASES OF THE DIFFERENT QUARTERS OF THE GLOBE.

EUROPE.—The continental portion of Europe presents the greatest contrasts in its climate, but it is generally temperate, owing to the extent of sea on its coasts, its numerous inland lakes and rivers, and the Gulf Stream of the Atlantic, the heated atmosphere of which is borne to its shores by the prevailing south-westerly winds. South of latitude 45° extreme cold is rare and of short duration, and the heat due to its position is tempered by the elevation of its mountains; but the southern coast-lands are blighted by the hot wind of Africa, the *sirocco*; and, from its exposure to the northerly winds from the Arctic Ocean, the great north-east plain has a severe cold climate.

Nearly every form of disease has its representative in Europe, but space will permit the mention of only a few of the more characteristic of these.[11] Cretinism and goître are indigenous in the Alps, and extend eastward to the Caucasus and the Urals, south to the high-lands of Bosnia,[12] and north to the mountains of Scandinavia. Typhus fever prevails chiefly between the parallels of 44° and 60° in Western Europe; and yellow fever has occasionally visited the Mediterranean shores of Spain and Northern Italy. Intermittent fever prevails in the Netherlands, in a portion of Sweden near the mouth of the Angermann river, where it has been endemic from time immemorial; on the shores and islands of the Gulf of Venice, in many parts of France, on the western shores of central Italy, &c., and indeed wherever marshes exist. It was formerly very prevalent in many parts of Britain, but has been nearly exterminated by drainage and cultivation. Consumption spares no portion of the region: and the plague is in Europe mostly limited to the eastern countries, in the plains of Hungary, and in Bosnia and Albania, between the parallels of 25° and 42°. Small-pox still ravages many countries where vaccination has not yet been introduced. This is especially the case in Turkey, where the practice is opposed, except in some of the larger towns of Servia and in Montenegro. But even in England the deaths from this loathsome disease are at the rate of 5000 per annum, and in the United Kingdom the number of attacks is estimated at 100,000 every year.[13] Leprosy and elephantiasis are still prevalent in Scandinavia; and *Pellagra*, or Italian leprosy, is most virulent between the parallels of latitude 43° and 46° in upper Italy, the south of France, and the north of Spain. The disease termed Plica Polonaica has long prevailed in the countries of Poland and in Tartary.

Among the islands of Europe, Great Britain is peculiarly healthy. Malta has a tropical climate in summer, and, from its rocky surface, is nearly as hot during night as in the day. The mean temperature in January is 57°, and in September 76°. Rain falls in torrents from December to February, and in frequent showers from September to November. March to September is dry and cloudless. The prevailing winds are south-east, south, and north-west. The *sirocco* blows from the south-east in spring and autumn, when the temperature rises to 95°; and the *gregale* from the north-east, with violent storms. Malta has frequently been visited by the plague.

ASIA.—The peninsula of Western Asia, from its peculiar formation and the elevation of its table-land, presents striking anomalies in its climatology and corresponding varieties in its temperature. The plague extends occasionally between the parallels before mentioned to the borders of Persia. Remittent fever prevails along both shores of the Red Sea and the Persian Gulf, but is not severe, except in the marshy districts at the mouths of large rivers; and dysenteric affections are seldom met with in either of these regions. The chief physical features of Persia are its vast central table-land, 2500 to 3500 feet above the sea, and the wide salt desert occupying its eastern provinces. South of the table-land, the country is parched and barren, and the heats of summer are almost insupportable. This country, like Beloochistan, suffers from a scarcity of water; but both are comparatively healthy, and not the seat of any remarkable disease. In Bokhara, intermittent fevers are prevalent at the end of August and beginning of September; they disappear with the first frost. In Tibet, small-pox is extremely dreaded, and the infected house or village is razed to the ground. Turner says few Tibetans are marked with small-pox; those seized fall victims to its ravages, or are destroyed. He saw many villages left in ruins on this account. Inoculation is practised in China, but not in Tibet. The other complaints are dropsy and liver disease; fevers are seldom fatal. India has every variety of surface, from the level of the sea to the highest mountains on the globe, and its climate partakes of all the changes due to its position and extent. The year has three seasons—hot from March till June, rainy from June to October, and temperate from October till the end of February. The monsoons regulate the hot and dry seasons; earthquakes and violent hailstorms are of frequent occurrence, and often cause great destruction to human life (see p. 66, and small map, Plate 20). The inter-tropical portion of India comprises the stations of Calcutta, Madras, and Bombay, with an area nearly equal to the northern extra-tropical portion. In Bengal the climate is hot and humid from April to November, the other months are cool and bracing. At Calcutta the mean annual temperature is 90°, and the fall of rain 64 inches. The rainy and stormy season is during the south-west monsoon, from June to September. Madras has a mean annual temperature of 83°, and a mean rain-fall of 51 inches. The north-east monsoon brings thunder and rain, but the country is sheltered from the south-west monsoon by the range of the Ghauts. In the hot season the cool sea-breeze called "the doctor" blows from noon to nightfall, and is followed by the sultry and oppressive land-wind, which prevails till noon of the following day. In April and May the south shore-wind produces severe rheumatism. At Bombay the mean temperature is 85°; it is seldom above 100° or below 70°; the mean rain-fall is from 66 to 80 inches.[1] At Delhi, 800 feet above the sea, the climate is dry, the rain-fall being only 20 inches. In the valley of Cashmere, 5000 feet above the sea, there is frost and snow in winter, and in July and August the thermometer rises to 80° or 85° at noon. At the Sanitarium of Darjeeling, 7500 feet above the sea, the mean annual temperature is about 50°—nearly that of London—and the rain-fall is 125 inches.

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[1] The effects of electricity are best known in thunderstorms, the geographical distribution of which may help to explain certain etiological phenomena. In the torrid zone thunder is very frequent, especially at the beginning and end of the rainy season. In the region of calms on the ocean it occurs almost daily; thence it decreases towards the north, and in the direction where the continental character of climate increases—that is, in the interior of the continents. It increases along the declivities of mountain-chains with narrow ridges. On the northern shores of the Mediterranean, in the south of France, Italy, and Greece, there are, on an average, 25 thunderstorms in a year; in Western Europe and Germany, 20; in the interior of Russia to the meridian of Moscow, 17; in the middle Volga, at Kasan, 9; and thence they decrease eastwards till at Nertchinsk there are only three in a year. The decrease of thunderstorms from the coasts to the interiors of continents, it will be observed, has a striking resemblance to the decrease of rain in the same direction (see *Physical Atlas*, Plate 21, p. 67). At Stockholm there are, on an average, 9, and at Bergen 6 thunderstorms in a year. Farther north the phenomenon is more rare, so that often several years pass without the occurrence of thunder. In Western Europe the great majority of thunderstorms occur in summer, only about one-tenth being in the winter season. In Eastern Europe they occur more frequently in winter. The interesting diagram of storms in the Atlantic Ocean, just received (March 1856) from Lieut. Maury, shows a great preponderance of thunderstorms in the North over the South Atlantic.

[2] Comptes Rendus, 1854, p. 783.

[3] Ann. de la Soc. Météorol. de France, tome iii. p. 41; 1855.

[4] Between the years 1810 and 1815, thirty-five ships of the line, and thirty-five frigates and smaller vessels of the British navy, were disabled by lightning, and several of the crews killed or injured. No accident has occurred since the introduction of conductors.

[5] Haeser, i. 70.

[6] At Lima, diarrhœa is endemic, and prevails at pretty regular but distant periods as an epidemic.

[7] In India this class of diseases causes 47 per 1000 deaths among Europeans, and 5 per 1000 among the native population.

[8] In Algeria the greatest amount of mortality arises from diarrhœa, dysentry, and liver disease.—Hermann, *De morbis qui Algerii occurrent*. In Malta one-seventh part of the annual mortality is caused by dysentery. In Egypt, disease of the liver is very prevalent. At Jerusalem, dysentery, diarrhœa, ague, and diseases of the lungs are the most fatal diseases; the former extends to the Black and the Caspian seas, including the greater part of Asia Minor, thence it extends, by the southern declivity of the Caucasus, to the table-land of Central Asia.

[9] Schleisner, Forsög til en Nosographie af Island, 1849.

[10] History of Greenland.

[11] For special districts, see the valuable work *On the Sanative Influence of Climate*, by Sir James Clark, Bart. London, 1846.—*Climate of Italy*, by Dr Burgess, 1852.—*Change of Climate*, by Dr Francis, 1853.

[12] Boué, Turquie d'Europe, tome iii. p. 556.

[13] The difference resulting from the compulsory practice of vaccination and its neglect is strikingly shown in Italy as compared to Ireland. In Lombardy, where vaccination is enforced, the deaths from small-pox are in the ratio of 1½ in 1000; while in Connaught they are at the rate of 60 per 1000.

The diseases of this vast region are as varied as its physical characteristics; those most prevalent in the lower districts are, among Europeans, dysentery, liver affections, fevers, and rheumatism; and among the natives, leprosy, elephantiasis, Guinea-worm, ophthalmia, and beri-beri.[2] On the delta of the Indus, and along the western and eastern shores of India, remittent fevers and dysentery are the chief diseases of Europeans, and from the valley of the Hoogley, along the shores of Aracan and Rangoon, they are endemic, and of frequent occurrence. Influenza is often very severe, and cholera comes every year in the delta of the Ganges towards the end of the hot season. Small-pox formerly committed great havoc, but of late the virulence of the disease has been checked by inoculation. Europeans have found great benefit from a temporary residence at the different Sanitaria established, at elevated stations in the sub-Himalayas, the Neilgherries, &c., where they can enjoy a temperate climate and exercise. Darjeeling affords instant relief from acute diseases; cholera is hardly known there, and when imported it does not spread: liver and bowel diseases are equally rare; and ophthalmia, elephantiasis, and leprosy, are almost never seen; but rheumatism and ague are frequent, as well as violent and often fatal remittents.[3]

The hill-countries of Gurwhal and Kumaon at the foot of the Snowy Mountains are visited by a pestilent disease termed "*Maha murree*," or "certain death," which is described as resembling the plague of Turkey, and as being so infectious that any one afflicted with it who dared to leave his village or hut was shot like a mad dog. It commences with violent pains, succeeded by swelling of the body: it is generally fatal in 24 hours and is said to cut off 99 of every 100 attacked. Goitre is prevalent in the valleys of the Himalaya, in the mountainous countries of Central Asia, and in the island of Sumatra.[4] Diseases of the liver and bowels cause one-half of all the deaths among Europeans in India; fevers are slight. Liver disease is almost unknown among the indigenous population; and consumption, which is slight among Europeans, is scarcely ever met with among the natives. The average mortality among British troops for all India is 57 per 1000, and for native troops 18 per 1000, or less than one-third. The mortality from cholera in India is less than one-half among the native than the European troops, and the average mortality among the native troops in Bengal is less than one-half that of the British troops at home.[5] Allowing for difference of circumstances, we find that the effects of climate are equally apparent among civilians; for, according to Mr Prinsep, the mortality among the most favoured classes in civil life, from 1809 to 1828 inclusive, was, in the Presidency of Madras, 23.8 per 1000; Bengal, 25.1 per 1000; Bombay, 31.7 per 1000; while among the same class at home, from 1801 to 1832, the mortality was only 9.1 per 1000.

The island of Ceylon has a hot and moist climate; on the sea-coast the temperature ranges from 68° to 90°,—the mean being from 75° to 80°. The north-east monsoon prevails from November to February, and the south-west from April to November, and any interruption of their regular courses greatly increases disease. The east part of the island is hot and dry, the west more temperate and humid. Rain-fall, 85 inches at Colombo, and 120 inches in the hilly districts. The diseases of Ceylon resemble those of India. Small-pox is always more or less prevalent, and ophthalmia is common in the dry season. The army-returns show a mortality among the troops of 75 per 1000, or five times more than in Britain. The climate of Burmah is comparatively healthy, but that of Aracan proved most destructive to the British troops in the campaign of 1824-1826, when in a short period from one-half to two-thirds perished. The chief maladies are fever, disease of the digestive organs, and cholera; consumption is said to be rare.

Malacca has an equable healthy climate,—the thermometer ranging from 72° to 85°; it is but little affected by the monsoons, but there are regular land and sea breezes. The principal diseases are remittent fevers, with occasional outbreaks of cholera. Singapore is remarkably free from the diseases of the surrounding countries. Sumatra has mountain chains rising to 15,000 feet above the sea, but its eastern portion is level or undulating, with marshy plains along the shores: temperature at mid-day 82° to 85°, but at sunrise not more than 70°. Thick fogs, storms, and water-spouts are frequent off the coasts. Java is traversed by a mountain chain from west to east, about 1000 feet in elevation, with volcanic peaks rising to 10,000 feet: its north coast is low and marshy, and is lined with numerous small islands. The mean annual temperature at Batavia is 78°.3; winter, 78°.1; summer, 78°.6: at mid-day it rises to 80° or 90°, and at night it falls to 70°.[6] Remittent fevers, dysentery, and cholera, are the principal diseases.

Borneo has low swamps and paddy-fields on the western shores, where dysentery prevails; the other diseases are remittent fevers and cholera, which latter are the diseases peculiar to the Moluccas; but Celebes, from its singular formation exposing it to every wind, is very healthy. The Philippines have a hot moist climate, and are subject to severe storms. Winter, during the north-east monsoon, is the most healthy season. The mean annual rain-fall is 98 inches. The natives are healthy, and longevity is common. The principal diseases are intermittent fevers in low situations, chronic dysentery, elephantiasis, leprosy, and the *berba*, a disease characterised by swelling of the abdomen. Cholera was epidemic in 1842. Disease of the lungs is less prevalent than in Europe. The coast of China, between the parallels of 20° and 40° north, is a most unhealthy region, especially during summer and autumn, presenting throughout a humid atmosphere, a marshy soil, and a rank vegetation. The most peculiar complaints are dysentery and intermittent fevers, ending in remittent fevers, and sometimes complicated with scurvy. Intestinal worms are also very common. The small islands adjacent to the coast are equally unhealthy, and the diseases are of a similar kind. Yellow fever has not yet been observed, but cholera has been severe on the coasts, and in the islands of Amoy, Hong-Kong, Chusan: and at Manilla.

New Guinea, *Australia*, and *Tasmania*, are exceedingly healthy, and cholera has not yet appeared. New Zealand, as well as all the islands of the Polynesian archipelago, are remarkably free from the more fatal maladies which infest the shores of Asia and Africa. The climate of Australia presents great variety. The mean temperature of spring is 72°, autumn 64°, winter 55°. In Sydney the thermometer is seldom below 40°, but at Paramatta it is frequently 27° in winter. At Adelaide, South Australia, it ranges from 48° in July to 101° in January, and at Melbourne from 54° in June to 73° in January. The air is very elastic. The hot winds, supposed to originate in the deserts of the interior, raise the thermometer in the shade to 117° or 120°; they wither the grass, and frequently destroy the harvest, but do not appear to affect the health of man. The diseases of Australia resemble those of Britain, but they assume a milder type; the principal are those of the alimentary canal, the respiratory organs, the brain and nerves, and rheumatism. Dysentery is occasionally severe in South Australia, Victoria, in the Digging regions preeminently, and Moreton Bay; but not in Sydney. The only part of Australia at which remittent fever has been known to prevail is Port Essington, on the north coast. Typhus has been introduced by ships, but it loses its virulence. Ophthalmia is common in South Australia, and in 1847-8 epidemic influenza was fatal to European children and the aged, and cut off 15 per cent of the natives. Pulmonary consumption is scarcely known among the aborigines, but small-pox is prevalent.[7] The mean temperature of Tasmania is about 70°, but during the hot winds from the north and north-west, it rises to 100° or 110°; the minimum is 31° in July. In the winter months, June, July, and August, frosts are occasionally severe in the high lands of the interior. The average number of rainy days is from 100 to 120, and the rain-fall 23 inches. The diseases resemble those of Australia, but the island is generally very healthy.

New Zealand.—At the time of Cook's first visit, the islands were remarkably healthy, but since their intercourse with Europeans the natives have rapidly declined. In 1848 the deaths of Europeans in the hospitals amounted to only about 9½ per 1000. Catarrhal disease was very prevalent in 1849. Influenza, scarlatina, consumption, and scrofula have made great ravages among the natives, and rheumatism is also prevalent among them, but these maladies are rare and mild among the English. The islands are almost exempt from remittent and intermittent fevers. Epidemic scarlatina of a fatal type appeared for the first time in 1848. Small-pox and measles have not yet visited New Zealand, and vaccination is extensively practised with the hope of warding off the former. A strange disease called "Ngerengere" (Lepra Gangrænosa), formerly prevalent among the New Zealanders, is now rare.

AFRICA, in so far as known, comprises the most healthy and the most deadly climates on the globe—the former at its southern extremity, and the latter on the west coast, where Sierra Leone has been termed the "white man's grave." Algeria, on the north coast, is traversed by the Atlas Mountains, which in the province rise to 7000 feet above the sea; on their northern slopes the climate is temperate and healthy, but it is pestilential in the marshy plains.[8] The heat is often excessive under the influence of the *simoom*, or hot wind of the desert. In 1846 there were fifty-six storms. The most fatal maladies are diarrhœa, dysentery, and liver disease.

On the west coast of Africa the shores and estuaries of rivers are low and marshy: the chief characteristic of the climate is excessive moisture, the average annual fall of rain at Sierra Leone being 189 inches, and the mean temperature 81°. The rainy season extends from June to September. After the rains, dense masses of vapour, termed the "smokes," envelop the land for days together, and are often driven to a considerable distance seaward. The temperature of the intertropical portion, from the Gambia on the north to Benguela on the south of the equator, is remarkably equable, the general range of the hottest period being from 80° to 86° in the shade on board ship, while at the extremities of the station in the winter months it is seldom below 58°; but sudden changes from excessive heat to cold, with chilling fogs, are frequent. Every part of this coast, and the adjacent islands between the tropics, is most deleterious to the health of Europeans, but much of the excessive mortality recorded there has been the result of imprudence.[9]

The most fatal climatal diseases are remittent fever and dysentery.[10] July to October, the rainy season, is the most unhealthy; from November to April fever is comparatively mild. Dysentery is most prevalent, both on shore and in ships, in the southern division of the station, probably owing to the use of the waters of the Congo river. It is frequent in all seasons at Ascension, but is not endemic at Sierra Leone. Inflammation of the liver is less prevalent here than in India, and consumption is little known. Among the natives, especially in slave-ships, the prevailing diseases are dysentery, fever, small-pox, rheumatism, lethargus, or "sleepy dropsy," and ophthalmia. Of the white troops who garrisoned the stations at Sierra Leone in 1824, two-thirds died in a year, and few lived to complete twelve months in the command. The annual mortality among the black troops is only from 2 to 3 per cent. The Guinea worm[11] infests the negroes, or others who have resided some time on the Gold Coast, or on the shores of the Bights of Benin and Biafra. Yaws and craw-craws[12] are also prevalent among the natives.

The climate of Loango is fatal to Europeans; its chief maladies are remittent and intermittent fevers. St Paul de Loanda has a climate intensely hot; fevers prevail, and ague and small-pox occur among the natives. Benguela is reported the most sickly of the Portuguese stations south of the equator: the heat is here excessive, and water deficient. At Little Fish Bay, latitude 15°.13 south, fever is not severe, and the southern portion of Africa, beyond the tropic on both sides, is remarkably free from remittent fevers. In the CAPE COLONY the climate may be termed temperate, the mean temperature is 67°, and the range is from 50° to 80°. Sudden changes are common: a veering of the wind from north-west to south-east often lowering the temperature 40° in one day: and the hot winds in May, June, and July, frequently blow with the violence of a gale, and raise the temperature 20° in course of a night; but this apparently does not injure health. The country is eminently healthy, and cannot be said to have any peculiar diseases. Dysentery sometimes attacks new immigrants, and many of the Hottentots die of consumption,[13] and present cases of leprosy. Diseases of the stomach and bowels are general, and rheumatism is severe and very prevalent; but fevers are of rare occurrence.

In Kaffraria and Natal the climate differs widely from that of the Cape Colony; here winter is the dry season. From May to August it seldom rains: in summer the rainy season sets in with terrific thunderstorms. In spring the temperature of the plains is seldom above 50°, in summer it is between 70° and 90°, and before storms it often rises to upwards of 100°. The country is remarkably healthy.

Madagascar is visited by pestilential fevers and dysentery on the west coast, and by aggravated skin-diseases in the interior.

The Portuguese colony of Mozambique is still a seat of the slave-trade, and it has long been notorious for its pestilential diseases. From Delagoa Bay to Magadoxo remittent fever and dysentery prevail at all seasons along the coast of Zanguebar, and extend a considerable way inland, but the more elevated portions of the country of the Imaum of Muscat are said to be healthy.

From the equator to the Strait of Bab-el-Mandeb, and along both shores of the Red Sea, remittent fever prevails in the marshy districts, at the mouths of large rivers. Remittent and intermittent fevers, dysentery and ophthalmia, are prevalent in Abyssinia.

Egypt.—The climate of the upper part of the Nile Valley is characterised by extreme dryness. The temperate season lasts from October to March, and the hot season from March to September. In summer, the heat during the day is excessive, owing to the confined position of the country and the low level of its surface, but the nights are cool and agreeable. In winter the weather is mild and pleasant. At Cairo the mean temperature of the year is 72°.2, winter 58°.4, summer 85°.1; and at Kenneh the mean is 79°.9, winter 63°.6, summer 92°. Upper and Middle Egypt are more healthy than the Delta. The annual inundation of the Nile commences in June, and attains its maximum height in September. After remaining stationary for some days, the waters again subside, when fevers, dysentery, and ophthalmia prevail over the whole country. The plague is endemic in the lower province, seldom passing south of Siout, on the Nile. North and north-west winds blow permanently during the progress of the sun towards the tropic of Cancer; but on his return to the tropic of Capricorn, it varies between south-east and west. At the spring equinox the pestilential hot wind, called the *Simoom* or *Khamsin*, blows from the south-south-west for fifty days. During this period the diseases peculiar to the country assume their greatest virulence. The *mirage* occurs on the extensive plains after the surface has been heated by the sun; the country then appears like a vast lake studded with islands. Rain is unknown in Upper Egypt; in the Delta it falls frequently from November to March. Showers are slight and infrequent at Cairo; the average number of rainy days there being thirteen in a year. Snow never falls except in the vicinity of the coast, and then in very small quantities.

AMERICA, NORTH.—The great characteristic feature of this division of the so-called New World is its vast interior valley, extending from the Gulf of Mexico to the Arctic Ocean, and presenting every variety of climate between the tropical and the polar regions. This valley is cut off from the genial influences of the Pacific Ocean on the west by the Rocky Mountains, and from those of the Atlantic Ocean on the east, but in a less degree, by the Alleghanies. (See Plate 7, p. 25.) It is traversed by a deep winding longitudinal depression, forming the trough of the Mississippi for more than 2000 miles. The climate of the north-eastern States is variable, with extremes of summer heat and winter cold, while the southern States enjoy more of a tropical climate. The Pacific coasts are milder, and in the north more moist than those of the Atlantic. The following examples show the decrease of temperature and rain-fall in proceeding from south to north:—

Place.	Latitude.	Temp. of Year.	Annual Rain in Inches.
New Orleans, ...	29.57	71.32	52
Cincinnati, ...	39.06	54.25	47
Washington, ...	46.22	53.13	34

Throughout the eastern half of North America, especially its middle latitudes, there are but three characteristic winds:—1. A damp and chill current from the north-east, visiting the whole Atlantic seaboard and the interior to about lat. 35°;—2. A south-west wind, extending from the Gulf of Mexico and the table-lands of the continent, the whole way to the basin of the St Lawrence, and even past it; and—3. A continental wind from the north-west, dry and cool, and very pure. The north-east wind blows on the fewest number of days in the year, except upon the north-east Atlantic coast, where it is very frequent. In the southern half of the country the south-west wind predominates, especially in summer and autumn; and in the northern half the north-west wind is in excess, particularly during winter and the latter part of autumn. Of the relations of these winds to disease, it may be stated generally, that the north-east is the *catarrhal* wind, disarranging most the respiratory organs; the south-west the *malarial* wind, disturbing most the functions of the liver; and the cool, dry, continental wind from the north-west is by far the most salubrious breeze on the continent, tending to repair the mischief done by the others, especially by the south-west.

In Louisiana the most fatal disease is the congestive form of fever, called the *cold plague*. Diarrhœa and dysentery prevail extensively, mostly south of the 40th parallel of latitude, and the Dengue, "break-bone" or "dandy" fever, is prevalent as an epidemic in the southern States. The same fever was observed at Rangoon and Calcutta in 1824, at Berhampore, &c. 1825, the island of St Thomas, West Indies, 1827, and New Orleans in 1828. A remarkable endemic disease, termed the *milk sickness*, is peculiar to the western portion of the United States, being seldom or never observed to the east of the Alleghanies.[14]

The mainland of North America, from the tropic of Cancer to Behring Strait on the Pacific side, is free from endemic diseases, but yellow fever has of late years appeared on the south-west coasts. From the parallel of 46° or 47° north to the polar regions, the inhabitants, with the exception of exanthematous diseases (eruptive fevers or rashes) and influenza, enjoy the most perfect immunity from the endemics and epidemics which infest the tropical regions. The Esquimaux have few ailments, and typhus fever and consumption are all but unknown in the arctic regions. Cholera first appeared in the ports of the United States in 1832.

Oregon has a climate well suited to the white race. The western section is mild and equable, resembling that of England; prevailing winds south and south-west on the coast; the middle section is dry and changeable, the temperature varying from 9° in January to 108° in July. In the eastern section the temperature fluctuates 50° or 60° in a few hours. No ague nor fevers were known to exist prior to 1830, but since then they have committed frightful ravages amongst the Indian population.

California is much milder in its climate than the corresponding countries on the Atlantic side, with short winters. At San Francisco the temperature is seldom above 80°, and rarely falls below 40° in the rainy season. Fogs are frequent in summer, from north-west winds. Snow is seldom seen on the coast. The sheltered valleys enjoy an excellent climate. In the valleys of the Sacramento and San Joaquin, the mercury often rises to 100° or 120°, and the air is extremely dry. The white population is exempt from climatic diseases, but in 1839 small-pox carried off one-half of the aborigines.

Mexico is traversed by the mountain chains which connect the Andes and the Rocky Mountains. These separate and enclose the table-land of Anahuac, 6000 to 8000 feet above the sea. The *Tierras Calientes* (hot lands) extend from the coast to about 900 feet above the sea; *Tierras Templadas* (temperate), 4000 to 5000 feet; and *Tierras Frias* (cold) above 7000 feet. The mean temperature of the coasts between the parallels of 15° and 20° is 76°, while on the elevated plains it is only 64°. The shores, especially those of the Gulf of Mexico, are excessively hot, humid, and unhealthy; while the plains of the interior, 3500 to 4500 feet high, have a temperate and perfectly healthy climate. The annual rain-fall at Vera Cruz is 185 inches. All the higher regions of Mexico are extremely healthy; fevers are confined to the coasts. The *Matlazahuatl* is a disease peculiar to the Indians; it resembles yellow fever. Small-pox was introduced to Mexico in 1520, when it destroyed one-half the population. In 1799 it destroyed in the city of Mexico alone upwards of 9000 persons.

The State of New Mexico is extremely salubrious. The annual range of temperature is from 10° to 75°, and the rainy season from July to October. Bilious diseases, the scourge of the Mississippi valley, are almost unknown here, but an epidemic fever, of a typhoid character, ravaged the country in 1848-9; and this, together with small-pox, which prevailed epidemically in 1840, carried off 10 per cent of the population.[15]

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[1] Bombay was formerly considered "the grave of Europeans," owing to the high tides which overflowed the island, and produced pestilent miasmata; but great sanitary improvements have been effected, and by the census of 1849 the mortality is said to be reduced to 1 in 29 of the population.

[2] This singular disease is most prevalent on the Malabar coast, and in the island of Ceylon, during the damp and variable weather at the change of the monsoons. Its name is derived from the waddling unsteady motion observed in patients labouring under it.

[3] Hooker's Himalayan Journal.

[4] Turner found goitre very common among the hills of Bootan and Nepaul; it is there called Ba or Ke ba, "the neck-swelling."—*Embassy*, p. 86. It can be traced from the frontiers of Assam, latitude 27° north, longitude 91° east, by the confines of Rohilcund to Hurdwar, latitude 30° north, longitude 78° 25′ east.

[5] The average mortality among troops in the United Kingdom is only about 15 per 1000.

[6] Batavia was formerly reckoned one of the most unhealthy places in the world; but since the canals have been filled up, and other sanitary improvements adopted, the climate is now healthy. "Java fever" is abolished from the city, and only appears at intervals in the small adjoining islands. The English population is much more numerous than at Calcutta, and I am assured by the British consular agent, that the principal physician in the island did not lose one English patient in 8 years (1840 to 1848). He remarks, that since fever has been abolished, consumption has been induced in its stead. Rheumatism is prevalent at the change of the monsoon.

[7] Organic lesion of the heart is often fatal among the settlers in the bush. It is said to resemble the "postboy's malady" of France, and is probably occasioned by excessive exercise on horseback.

[8] Mean temperature of year, 69°.13; mean rain-fall, 36 inches; rainy season, November to April; dry season, May to October; rainy days, 95 in the year.

[9] See Notes on the Diseases of Sierra Leone, by R. Clarke (Journal Statist. Soc., 1856, p. 60). Fernando Po was abandoned as a government establishment in 1832, on account of its sickly climate. During its occupation, the mortality from fever, consumption, and dysentery, was frightful.

[10] Remittent fever prevails more or less in all the Cape Verd islands during and after the rains. Cholera prevailed at Fogo in 1855, and at the Grand Canary Island in 1852. Yellow fever appeared at Fernando Po in 1828-9, at Goree and St. Mary's in the Gambia in 1838 and at Sierra Leone in 1837-38-39 and 1847, but it has never been known to occur at any of the European settlements on the Gold, Grain, or Ivory coasts, nor at the slave depôts or native towns on the banks of the rivers which flow into the Bights of Benin and Biafra. It has visited the Island of Ascension twice, first in 1828, and again in 1838 (Bryson), and Boa Vista on one occasion only, in 1845-6, when it was introduced by H.M.S. Eclair (*vide* Report by Dr M'William to Parliament, 1847). Its southern limit on the west coast is Fernando Po.

[11] The *Dracunculus*, or Guinea-worm, is about the thickness of a violin string, and from 6 to 24 inches in length. It insinuates itself among the muscles of the feet and ankles, causing lassitude, sickness, and fever. Its extraction is very difficult. This is a prevalent and very serious disease among the troops in India, especially in Bombay Presidency.

[12] These troublesome maladies resemble the itch of Europe, but are much more inveterate; they are engendered by filth, and depravity of the blood.

[13] Consumptive patients find a residence on the mountains, 8000 feet above the sea, highly beneficial.

[14] It received its name from the circumstance, that it is frequently communicated to man by the use of the milk of an infected animal. Among horses, oxen, goats, and sheep, it is known by the name of the *Trembles*. In many cases it terminates fatally. Recovery is very tedious, and accompanied by loss of memory. It comes at all seasons of the year. Within the limits of its prevalence, whole communities of the early immigrants were often compelled, on account of it, to seek another location; and even now, those residing within an infected district, only escape the disease, by abstaining from the flesh or milk of cattle living within the same limits.

[15] Among the native tribes of North America no disease has committed such havoc as small-pox: the aborigines have no remedy, and blindly submit to its ravages. It spreads among them periodically, at regular intervals of time, and has been one of the principal causes of their depopulation. Ardent spirits have in the long-run caused greater mortality, but their effects have been comparatively slow, and not so revolting. This malady swept through the Missouri Valley in 1837; it broke out among the *Mandans* in July. This tribe, which consisted of 1600 persons, was reduced to 31. It next attacked the *Minnetarees*, and reduced them from 1000 to about 500. The *Arickarees*, numbering 3000, were reduced to 1500. The disease passed to the *Assiniboines*, a tribe of 9000 living north of the Mississippi, and ranging in the plains below the Rocky Mountains towards the Red River of Hudson Bay, whole villages of whom it nearly annihilated. The *Upsarokas*, or Crows, estimated at 3000, lost nearly one-third of their numbers. It then entered the tribe of the *Blackfeet*, estimated at 30,000 or 35,000, among whom it destroyed the inmates of 1000 lodges, each containing from six to eight persons. At a moderate calculation, no less than 10,000 persons fell before this terrible disease in a few weeks.—*Schoolcraft's History of Indian Tribes of United States.* Philadelphia, 1851.

In *Central America* the climate is remarkable for its variety of temperature produced by difference of altitude, and its equality during the different seasons of the year. On the south-west coast the rainy season begins in May and ends in October. During the rest of the year rain is almost unknown. On the north-east coast the rains continue nearly all the year, the driest period being from June to October, and the wettest from October to May. The excessive moisture renders the north-east coast very unhealthy, while the rest of the republic is, considering its position, comparatively salubrious. On the table-lands (los Altos) the temperature is mild, and in the higher stations it is excessively cold. In Guatemala the temperature is seldom above 80° or below 50°. Many of the largest towns, as Sonsonate and San Miguel, being little above the level of the sea, have an oppressively hot temperature of 80° or 90° at all seasons. Honduras has a very unequal surface, and the capital town, Comayagua, has a hot climate; but many parts of the interior have a fine temperate climate, similar to that of Southern Europe. Belize is reckoned more healthy than most of the West India islands: the mean annual temperature is 80°: rains are frequent in July, August, and September. Omoa and Truxillo on the north-east coast have an excessively hot and unhealthy climate. Yellow fever occurs on all the coasts of the Mexican Gulf, and goitre is prevalent in the mountainous districts. At Porto Bello the "vomito negro" has often nearly depopulated the place.

West India Islands.—The space between the equator and the parallel of 40° north, including the shores of the Caribbean Sea, the Gulf of Mexico, and part of the Atlantic shores of the United States, with all the West India islands, is the true domain of yellow fever. Remittent fevers also, the endemic of hot countries, and dysentery,[1] prevail at all seasons, occurring most frequently in marshy places. This is, besides, the region of hurricanes, and the theatre of many epidemic diseases. But although all the islands are included within the pestilential limits, they present a great variety in their comparative liability to and exemption from particular forms of disease.

Cuba.—This island is within the influence of the torrid zone, but the climate is changeable and cold during N.N.W. winds. The hottest months are July and August, when the temperature is 82° or 84°. In the coolest months, December and January, it falls to a mean of 63°. In 1804 it fell in three hours from 89° to 73 in the shade. In 1801, after some weeks of north wind, the water froze to the thickness of a few lines, at an elevation of 373 feet, near Havana: the same phenomenon occurred in 1812. The mean annual temperature at Havana is 77°, the highest observed is 90°, and the lowest 50°, Fahr. At Santiago the mean is 80°, the hottest 85°, and the coolest 73°; but it has been observed as high as 93°. The average of rainy days at Havana is 102. The mean annual fall of rain is 45 inches. It is observed that hurricanes recur every second year, in September and October; (See Table, *Physical Atlas*, p. 62.) The towns on the coasts are inimical to the health both of the black and white population: the western portion of the island is the most unhealthy, and the central least so. The greatest mortality occurs between the years of twenty and thirty, the age at which the greatest number of immigrants arrive. The most fatal months for the Creoles are March, February, January; the least so, November, December, June. The most fatal months for Europeans are June, July, August, May; and the least so, January, February, March, November, and April. Intermittent fever prevails along the rivers of Cuba, but yellow fever does not extend to the interior.

Porto Rico has a climate generally more healthy than the other islands of the Antilles. Cholera broke out in December 1855, and extended over eight towns. In 301 cases reported, 123 had died, 32 recovered, and 146 remained still sick.

In *Jamaica* the climate varies greatly at different elevations, being hot and oppressive in the plains, and cool and fragrant on the mountains. At Kingston the mean annual temperature is 80°, while at Pleasant Hill, 4000 feet above the sea, it is from 52° to 65°. The amount of rain at some seasons is very great, varying from 70 to 100 inches. When first occupied by Europeans, the climate of the island was considered salubrious, and longevity was common. In the mountains the climate is peculiarly healthy, and they are now a favourite resort for American invalids. The chief diseases are yellow fever, remittent and intermittent fevers, diarrhœa, dysentery, rheumatism, and influenza. The negroes suffer from ulcers and *yaws*, a species of leprosy. Cholera appeared for the first time in October 1850, at Port-Royal, thence it spread over different parts of the island. It is calculated that in 1850-51, a fifth part of the population was attacked with the severe form of the disease, and the deaths are estimated at from 30,000 to 50,000. By the removal of the troops to Newcastle, 4000 feet above the sea, the mortality among European soldiers has been diminished to one-fourth its former amount. Yellow fever, in its most virulent form, appears very frequently at Port-Royal.

Barbadoes.—Climate equable, and comparatively dry; temperature from 77° to 84° Fahr.; annual rain-fall 72 inches; prevailing wind north-east. The island is subject to terrible hurricanes and earthquakes; thunderstorms are frequent and severe. It, as well as Antigua, is frequently visited by yellow fever of a severe type.

St Lucia.—Temperature of the year from 75° to 90° Fahr.; annual rain-fall 84 inches. The island has long been noted for its insalubrity, the chief diseases being fevers, and diseases of the stomach and bowels.

St Kitt's is extremely dry, and comparatively healthy.

Tobago.—The climate of this island is healthy, on account of its narrowness, and the regularity of the land and sea breezes. The thermometer ranges from 75° to 90°. Fever is prevalent.

Trinidad is in general healthy, but fevers are severe. The thermometer ranges from 70° to 85°, and the fall of rain is 75 inches. The hot and rainy season extends from June to October, but hurricanes are unknown.

Bahamas.—The climate is equable, the temperature varying from 73° to 93° Fahr. The islands are resorted to by Americans afflicted with pulmonary complaints. Cholera has never visited the Bahamas.

The *Bermudas* are generally healthy; the thermometer from 60° to 70° Fahr. In 1842 epidemic influenza raged with great violence among the white population, but the blacks were very slightly affected. Rheumatism is prevalent, and dysentery and yellow fever prevail occasionally. Remittent fever is not severe.

Canada.—The climate of this vast country varies according to position and elevation. It is everywhere liable to sudden changes. In the eastern province the winter is more severe than in the west, but the clear blue sky, and the absence of fogs, indicate its great salubrity. The mean annual temperature of West Canada is 48°.37; and of East Canada 42°.1. The annual fall of rain is nearly the same as on the east coasts of Great Britain. At Quebec the mean winter temperature is 14°.2 Fahr.; but it is sometimes as low as 60° below the freezing-point. The prevailing winds are westerly. The severest winters are accompanied by north-east winds. The heat of summer is less relaxing, and the cold of winter more bracing, than in the United States. As the country becomes cleared, and has its swamps drained, its inhabitants may hope to enjoy a climate as salubrious as that of Britain. During the *Indian Summer*, in November, the temperature is mild and serene, with a hazy atmosphere. The principal diseases are ague and typhus fever; the former most prevalent in Western and the latter in Eastern Canada.

Newfoundland.—The climate is less severe than in Canada; the frost is less intense, and snow does not lie long on the ground. It is subject to dense fogs, chiefly in May and June, but these do not appear to injure the health, and the climate is remarkably salubrious. The chief diseases are those of the lungs, catarrhs, and phthisis—next, those of the liver and of the stomach and bowels, fevers being small in proportion. The mortality, according to population returns, is only 1 in 76; but the return of the troops in the station is much less favourable.

Nova Scotia.—Climate very moist; fogs are common along the coasts in May and June; changes of temperature sudden and extreme; range of thermometer, 6° or 8° below zero in winter, to 88° in summer. The air is highly salubrious; the inhabitants enjoy a remarkable degree of health, and an almost total exemption from the intermittent and remittent fevers of Canada and the United States.

Cape Breton has a similar climate, and is even more healthy, no epidemic disease, except small-pox, having been known for many years previous to 1834.

Prince Edward Island has a more severe winter, the thermometer being often 20° to 25° below zero; and the rivers and bays are frozen till the end of April. The army returns show a mortality of 14 per 1000, the chief maladies registered being diseases of the lungs, fevers, and rheumatic affections. Epidemic cholera did not visit Nova Scotia or New Brunswick in 1832, when it raged in Canada, but it appeared at Halifax in July 1834. It did not extend beyond the limits of the town. In 1849 the course of cholera in British North America was nearly the same as in 1834.

South America, from its peculiar formation, having a girdle of lofty mountains along its western side, and no corresponding continuous chain in the east, discharges nearly all its waters eastwards to the Atlantic Ocean, through the great basins of the Orinoco, the Amazon, and the Rio de la Plata. (See *Physical Atlas*, p. 27.) In general its climate is colder, and more moist than the corresponding portion of the Old World. Among the causes which produce this effect, Humboldt assigns the extension of the narrow part of the Continent towards the south pole; the expanse of ocean over which the trade-winds blow; the flatness of the eastern shores, and the current of cold water on its western coasts; the lofty mountain-chains, whose snow-clad summits cause currents of cold air to roll down their declivities; the numerous large rivers, which, after many windings, seek the most distant shores; the grassy steppes, which are not susceptible of acquiring a high temperature; and the impenetrable forests, near the equator, screening the alluvial soil from the direct rays of the sun, and exhaling vast quantities of moisture.

Venezuela has a hot dry climate along the shores of the Caribbean Sea, but Caraccas, 2822 feet above its level, is healthy. The table-land near the coast has an annual temperature ranging only from 70° to 80°. In the Llanos, or plains, the climate is unhealthy. The climate of *British Guiana* is excessively moist. In 1830 it rained continuously, except during September and October. In 1831 the rain-fall at George Town was 157 inches. The mean annual temperature is 81°, max. 90°, min. 75°; nearly the same in Demerara and Berbice. It is not subject to hurricanes. The most unhealthy season is from June to October. The chief maladies are intermittent and yellow fevers,[2] stomach and bowel complaints, and disease of the lungs. Spleen diseases are common as a consequence of intermittent fever, especially among immigrants. *Yaws*, an African malady, common during the time of slavery, has almost entirely disappeared, and the same may be said of leprosy. Elephantiasis is very common among the coloured population.[3]

Brazil has, on the whole, a mild and healthy climate. The rainy season commences with thunderstorms in October, and lasts till March. The mean temperature at Rio is 72°. The clearing of forests here has reduced the amount of rain so as to render the water-supply deficient. Para, formerly remarkably healthy, and free from epidemics of any kind, was visited by yellow fever in February 1850; its period of greatest malignity was during April, when the deaths in the city were twenty to twenty-five per day. About the same time in the following year, yellow fever having greatly abated, small-pox broke out with great violence, and by these two diseases about 25 per cent of the population was carried off. Cholera appeared for the first time at Para in May 1855, it reached Bahia in the middle of July, Rio de Janeiro on the 20th of the same month, and Pernambuco in February 1856. At Rio the whites died at the rate of 1 in 126 of the population, while among coloured people the proportion was 1 in 52. The climate of Para is delightful, but its filthy condition is a fertile source of malaria. At Santarem, in the province Para, elephantiasis and leprosy are common among the poorer classes. Bahia was long celebrated for its general health, and its freedom from cholera, influenza, and dysentery; but it also was visited by yellow fever for the first time in November 1849, although a similar epidemic is said to have been observed at Bahia and Pernambuco, between 1612 and 1686.[4] A species of typhus, termed *febres malignas*, commencing as ague or remittent fever, is prevalent on the coasts of Brazil, and cretinism and goitre are common in the mountain valleys of the interior. Elephantiasis, or the "Barbadoes leg," is still frequently met with, although it is decreasing among the white population; and the frightful malady termed *elephantiasis græcorum*, or tubercular elephantiasis, a species of leprosy, is common at Bahia, where there is a hospital for lepers. Insanity, nervous and pulmonary diseases, formerly rare, are greatly on the increase since the independence of Brazil. Hepatitis, though not so general as in other hot countries, is also on the increase.

Paraguay is described as generally very healthy, its tropical heat being modified by the inequality of its surface; yet it is occasionally ravaged by the most fatal maladies. In ten years previous to 1840, 20,000 persons died of dysentery; from 1836 to 1838, 11,000 died of scarlet fever; and in 1844-5, 14,000 died of small-pox,[5] and this in a population of about 200,000.

Buenos Ayres has a climate esteemed one of the healthiest in the world, and instances of longevity are common. The *pampero*, or south-west wind, is often a hurricane, bringing clouds of dust from the parched pampas, and causing complete darkness, which lasts for half an-hour in the middle of the day; and the *viento norte* (north wind), is very severe, producing great irritability and headache, chiefly among the native women. Small-pox formerly cut off thousands of Indians, and its ravages are still very severe among them, but it has been greatly arrested by vaccination. Intermittent fever is hardly known. The most fatal diseases in the hospital in 1828 were consumption, fever, and inflammation of the liver. At the *Falkland Islands* the climate is more equable than in England; the temperature ranges from 30° to 50° in winter, and from 50° to 75° in summer; snow seldom lies on the ground more than half an inch thick; rain is frequent, but mild. Prevailing winds, north-west in summer, south-west in winter. The islands are very healthy; no peculiar disease has appeared, and those afflicted with pulmonary complaints are said to experience relief while resident in the islands.

On the west or Pacific coast of South America remittent fever, but not of a severe type, extends from Panama to near Lima, latitude 12°.3 south, and yellow fever has appeared on the coasts as an epidemic several times; but the Galapagos Islands, near the centre of this district, have escaped these maladies, and are remarkably healthy.

New Granada has an extremely varied climate; at Honda, 1000 feet above the sea, the heat is intense. Mompox has a dense moist atmosphere, and goitre and malignant ulcers prevail. At Cartagena the yellow fever is endemic, but in the elevated regions of the Andes the air is highly salubrious, with a temperature of 55° to 70°. On the coasts of Ecuador at Guayaquil, the country is inundated during the rainy season in July, after which it remains for some months a pestilential marsh; here yellow fever has appeared several times. At Quito, 9543 feet above the sea, there is perpetual spring, with a mild and equable and healthy temperature, but it is disturbed occasionally by violent winds and devastating earthquakes.

Peru has a hot and dry climate on the Pacific slope, where rain never falls, but it is tempered by the numerous streams which descend from the mountains, by the "garua" fog, and by the current of cold water from the Antarctic Ocean. The prevailing winds on the west of the Andes are south-west and south, which are dry and cool, but on the east the regular easterly trade-winds from the Atlantic are loaded with moisture, and pour down on the slopes of the mountains a copious, and in many places a perpetual rain. In the mountains, at the height of 3000 to 5000 feet, the temperature is mild, equable, and healthy, and the inhabitants are noted for longevity. At Huanuco, 5946 feet above the sea, no chest-affection is known to originate, and the city is resorted to by consumptive patients from other places. Dysentery, and a putrid fever called *tobardillo*, are the commonest maladies, and goitre is prevalent, especially among the women. At Lima, 453 feet above the sea, the mean temperature of the year is 73°.3, winter 68°.1, summer 77°.6. The climate is pleasant, and it was formerly reckoned healthy, although the mortality was always excessive from neglect of sanitary measures. Yellow fever has recently appeared, and ague prevails along the entire coast of Peru, at all seasons, and among all classes of the population.

Bolivia has three regions of climate,—the *Puno*, high and cold, including the district of Lake Titicaca, 12,846 feet above the sea; the *Paramo*, temperate; and the *Yungas* or valleys, hot. The table-land has clear skies for nine months of the year, and three months of rain. The higher regions are healthy, but fevers prevail in the valleys.

Chile has in its central districts a hot dry climate, the thermometer in summer rising to 90° or 95°; on the coasts it is finer and more temperate; ice is sometimes seen in winter and spring. Rain falls between June and September south of Copiapo; it is irregular, and often very heavy. Goitre is prevalent in the Andes, especially in the province of Mendoza, but otherwise the climate of Chile is noted for salubrity.

The regions of *La Plata*, and the northern and eastern frontiers of *Patagonia*, are characterised by extreme dryness, for the rains carried by the prevailing winds from the Atlantic are exhausted before they reach the interior plains, while those brought by the south-west winds are arrested by the Andes on the west coast of Patagonia, which is excessively moist. Goitre is not known to extend farther south than about latitude 44° south.

EPIDEMICS.

Diseases of this class are to a great extent limited to the regions of their birth, and in this respect are to be considered as endemic; but they make occasional outbreaks at longer or shorter intervals, and extend over a greater or less extent of surface. In quitting the regions of the torrid zone, or countries having a tropical climate, they lose their intermittent type. The entire class has certain marked peculiarities by which it is distinguished. They always attack a great number of persons at once; they all bear the characteristics of fever; and each resembles the other in having a certain range and a periodical recurrence.[7] It has been ascertained that nearly every epidemic on record was preceded by influenza. Some of these diseases, as yellow fever, are peculiarly fatal to those who are strangers to the soil; while others, as cholera, attack the native and the unacclimatised alike. Among the best known and most interesting examples of this class are—

1. *Yellow Fever.*[8]—The first trace of this formidable malady was observed, at the end of the fifteenth and beginning of the sixteenth century,[9] at San Domingo and Porto Rico: on the continent of South America, and on the Gulf of Darien, at which latter place it prevented the Spaniards from settling. From 1544 there is no record of the disease having broken out anywhere till 1635, when it appeared in Guadeloupe. Thenceforward it occurred at irregular intervals. In the seventeenth century it spread along the continent of South America to latitude 8° south, and in North America to latitude 42° north, but only on the eastern coasts of both. The first notice of it on the Gulf of Mexico was at Biloxi Bay in 1702, and Mobile in 1705.[10] The next was in Pensacola and Mobile in 1765, where it prevailed as an epidemic. In the eighteenth century it appeared on the west coast of South America to latitude 2° south, North America again to latitude 42° north: in Europe, and even in the islands of the Pacific, and in Madagascar. At the beginning of the nineteenth century it extended, in North America, to latitude 47°, in Europe to latitude 48° (the Canary Islands and Leghorn), and penetrated deeper into the American continent than formerly.[11] "Ever since yellow fever attracted attention, or was recognised as a distinct disease from the remittent autumnal fevers of the temperate zone, it has prevailed as an endemic at Havana, raging epidemically from April to December, and occurring sporadically throughout the remainder of the year."[12] From time immemorial it has been indigenous at Vera Cruz, on the Gulf of Mexico. Here its chief victims are strangers who come from colder regions during the hottest season, as well Europeans as those natives who quit the interior for the coast region; and hence it is termed the "strangers' fever." The yellow fever is a disease of hot weather, requiring for its manifestation a high mean temperature. It never appears in any climate where the temperature falls below a certain average. It has often prevailed in almost every town on the Mississippi up to Vicksburg, latitude 32°. 24′ north, but has never, except once, reached Memphis, in latitude 35°. It occurs with an early hot summer, when the rain is not copious enough to flood the marshes; but heat alone is not sufficient to engender it.[13]

Among causes hitherto little adverted to, but which by some authors are held to be essential to the production of this fever, is a certain degree of density of the population. Thus Jörg[14] affirms, from personal knowledge and the observations of others, that this fever never occurs in the country or in small villages, but always in large cities, or smaller towns with great trade.[15]

Limits.—Since this disease is dependent, in a great degree, on an elevated temperature, its occurrence is necessarily limited to the tropical regions, or to countries having a tropical climate. Within these prescribed limits in many places the exciting causes seem to exist, but still the fever has never or seldom shown itself. Its proper seat is the West India Islands and the Bahamas, with portions of the adjoining continents of North and South America. From Brazil to Charleston in one direction, and from Barbadoes to Tampico in another, the exciting causes are in constant though unequal force, depending on different seasons and localities. The fever prevails often, though not generally, in places north of Charleston; visits occasionally the Atlantic cities of the United States, and has ascended as far as Boston; while in the Mississippi Valley it once appeared as high as Memphis.[16] In an eastern direction, but within the same parallels, it has extended to Cadiz, Xeres, Carthagena, Malaga, Alicant, Seville, Barcelona, and other cities on the coast and in the interior of Spain. It has prevailed several times at Gibraltar, once at Rochefort, once at Lisbon, and once at Leghorn. It reaches to between latitude 22° or 23° south of the equator, and to 42° north on the Atlantic coast: to 35° on the western waters of the interior, and to 8°.56 on the Pacific. In longitude it extends from 60° to 97° west, or, including Europe, to longitude 10° east. Until recently the river Amazon formed its boundary south of the equator; but since 1850 it has invaded Rio Janeiro, Bahia, Pernambuco, and other parts of Brazil. On the Pacific it only appeared once at Panama, twice at Guayaquil, and once at Callao. It does not appear in the East Indies. It has never prevailed in China, Cochin-China, Singapore, Siam, or Ceylon; it prevails only occasionally on the west coast of Africa, Senegal, and the Gold Coast; and has been only three times in eighty years at Cayenne.

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[1] Dysentery is not a common disease in the West Indies generally, but it may be said to be endemic in the Bermudas.

[2] Epidemic yellow fever commenced in Brazil, and spread through French, Dutch, and British Guiana, and thence to the West Indies, New Orleans, and Bermuda. It appeared at Cayenne in November 1850, Surinam January 1851, in the course of which year malignant influenza broke out in British Guiana, which, at the end of the year, was followed by yellow fever. The focus of the disease was at the mouths of the rivers and in the islands.—(*Report on Yellow Fever Epidemic*, By Dr Blair, Surgeon-General, British Guiana.)

[3] Dr Mushet of Berbice.

[4] From Bahia yellow fever extended to Pernambuco, where of all foreigners attacked 16 per cent died, and of the natives only 3 per cent. It reached Rio de Janeiro in December 1849. Here, while the fever raged along the flat coasts, the mountain districts of Petropolis (about 3000 feet above the sea), Constantia, &c., continued perfectly healthy.—(Dr M'William *On Yellow Fever Epidemy in Brazil*, 1851).

[5] Sir W. Parish, *Buenos Ayres*, p. 269.

[6] Tarma, in the province Pasco, 9738 feet above the sea, is very healthy, and the resort of invalids from Lima. At Cerro, 13,802 feet high, the temperature is 44° in the day, and 35° at night. In July, August, and September, hail and snow storms are frequent. The miners suffer from paralysis. Pleurisies and rheumatism are common, as well as the putrid fever called *tobardillo*.

[7] This was strikingly exemplified in the case of the epidemic erysipelas of North America in 1849. Its march was from north-east to south-west, through 15° of latitude, from the estuary of the St Lawrence to the delta of the Mississippi, the same route followed by the typhus epidemic of 1806-1816, and the epidemic cholera of 1832.

[8] In medical works this disease is described under more than thirty different names, none of which is felt to convey a correct idea to an observer. Besides the true yellow fever of America and the West Indies, several other epidemical diseases have similar appearances, and assume the same name, such as ship and hospital fevers.

[9] In December 1494, Columbus landed at San Domingo with 1500 Spaniards, in order to found the city of Isabella. A fever carried off the greater number of them. The disease is described as being "yellow as saffron or gold;" hence its name, although the yellow complexion is not at all a constant concomitant of the disease.

[10] New Orleans Medical Journal, vol. i.

[11] Drake, vol. i. p. 47.

[12] Röser, "Krankheiten des Orients," says he observed it also in Smyrna.

[13] Yellow fever is not known at Cumana, on the coast of Coromandel, at Manila, Madagascar, Egypt, and many other places where the heat equals or exceeds that of the West Indies, and the mortality varies extremely in places where the temperature is the same. In the West Indies there is in some seasons twenty times more mortality than others, without any change of temperature. As in the case of the plague and other malarial diseases, the yellow fever always occurs during the drying process. The West Indies, the southern States of America, the west coast of Africa, and all fever regions, are very humid. At New Orleans, Charleston, &c., yellow fever always occurs near the water; but the disease does not depend for its increase or severity on the absolute amount of rain. The average mortality of the troops in Jamaica is at least double that of British Guiana, although in the latter the rain is more than half as great as in the former place. Paucity of water in places where it previously and recently existed, and a surface capable of absorption, provided this paucity be short of actual dryness, is one of the most active causes of this malady. In the terrible epidemic of Cadiz in 1800, no rain had fallen for seventy days. On the other hand, excessive heat or dryness prevents or arrests the progress of the disease. Yellow fever appears to be the offspring of a special miasma, resulting from the decomposition of vegetable, and the disengagement of mineral substances, and not the product of a specific contagious poison. Its long absence from Philadelphia is partly accounted for by sanitary improvements, and on its return in 1853 it was much milder than on many former occasions.

[14] Dr Edward Jörg, Einflusses des Tropenklimas. Leipzig, 1851.

[15] Michaux (Memoire sur les Causes de la Fièvre Jaune, Paris, 1852,) with special reference to the United States, assigns three principal causes: 1. The agglomeration of inhabited houses contiguous to each other, and forming a town with a population not less than 1500; 2. That this town be built on the sea-shore, or immediately on the banks, and near the mouth, of a tidal river; and, 3. A high degree of heat persisting during a sufficient length of time, and not interrupted by a sudden fall of temperature. But neither of these causes alone are sufficient to excite the disease; it requires the combination of the whole. The yellow fever regularly decreases with the approach of cold weather, and disappears after the first frost. In direct opposition to the occurrence of intermittent fever, the yellow fever is "almost limited to the cities and towns, and is far more frequent in those on the banks than those remote from the Mississippi. With few exceptions, it has prevailed in no place not visited by ships or steamboats. Woodville, twelve miles from the Mississippi river, is the greatest distance from a navigable river at which it has as yet appeared."—Drake, vol. ii. pp. 189, 351.

[16] In North America its limits correspond nearly with those of the live oak, cypress, and long moss, and it will not, any more than they, be found among apple orchards, wheat fields, and groves of blue ash, sugar maple, and the arborescent buck-eyes. The remarkable coincidence of the occurrence of yellow fever with the geological formation of the soil will be seen by a comparison of this plate with Map No. 8, in which the limits of the tertiary formation indicate very nearly the boundaries of the epidemic.

Perpendicular Distribution.—From a similar cause, decrease of heat, the yellow fever never appears beyond a certain elevation. At Xalapa, in Mexico, on the same parallel as Vera Cruz, but 4330 feet above the sea, it is unknown. Maroon Town, and the Phœnix Park, Jamaica, are noted for healthiness, and while the pestilence of yellow fever rages in the low grounds and along the coasts, cutting off thousands annually, these elevated regions enjoy a complete immunity from its effects; for that bane of European life has, according to Major Tulloch, never been known, in any climate, to extend beyond the height of 2500 feet.[1] The inner Cabrite 430 feet, and the outer Cabrite 580 feet in elevation, are also remarkably healthy. In the island of Grenada, Mount Cardigan, 500 feet, and Richmond Heights, 730 feet, are not sickly. Mount Desmoulin, near Roseau, in the island of Dominica, 1500 feet above the sea, has invariably been free from yellow fever. The same immunity has been observed in San Domingo, in the mountainous parts of which, whatever be the nature of the soil, this disease does not prevail. In the United States the yellow fever is never known to prevail in very high situations, whatever be the condition of the localities; but at what point it ceases to appear or prevail, is still an unsettled question.[2] The disease varies in intensity, and in the numbers attacked, according to latitude. M. Moreau de Jonnés shows, by elaborate statistics, that in the United States the mortality amounts to one half of those attacked, while in Spain it is limited to a third or a fourth of the total number.[3] This is accounted for from the difference of climate and soil between Europe and America, which in winter is so extreme, that in order to find in Europe a cold as intense as that of the United States, it would be necessary to remove 12° or 14° farther to the north. (See *Distribution of Heat*, Phys. Atlas, Plate 18.) The portion of the United States visited by yellow fever has more rivers than Europe, in an equal extent of territory. The more southerly part of it is flat, generally sandy, and covered with the long-leaved pine. Large rivers descend from the Alleghanies; many of them are muddy, and their banks submerged during six months in the year; and the swamps thus formed are covered by thick forests of cypress and other trees. In these marshes rice-fields are established, and it is during the rice harvest in September that the autumnal intermittent fevers appear, by which nine tenths of the white population are attacked. Of the twelve principal ports of the United States, proceeding from south to north, the first nine, viz., New Orleans, Mobile, Savannah, Charleston, Wilmington, Norfolk, Baltimore, Philadelphia, and New York, unite, in different degrees, the three principal causes of yellow fever; and, consequently, the disease may occur in either or all of them; while in the other three, New Haven, Boston, and Portsmouth, one cause—a great intensity of heat—is wanting, and hence the disease is not often manifested there.[4]

However violent the disease may be at New Orleans, Savannah, or Charleston, no new case ever appears from the day on which it freezes even a single degree. This usually occurs, in the middle States, from the 25th to 30th October, and in the Southern States a month later. It often happens that in the Southern States the disease does not appear at all, if the summer has had frequent alternations of moderate temperature, owing to the occurrence of storms or refreshing rains.

The cessation of yellow fever with the approach of cold weather is so well known, that the farmers of Georgia and the two Carolinas, who, for security, remain in the country during the hot season, hasten to market with their produce about the beginning of November. They encamp within two or three miles of Charleston, where they wait with the greatest impatience the first appearance of frost, after which, with a feeling of perfect security, they enter the city in a mass, creating the utmost activity in the streets, which, a short time before, were nearly deserted.[5] The more wealthy inhabitants of the Southern States quit the country during autumn to escape intermittent fevers, and the cities to avoid the yellow fever, and spend the sickly or hot season in the Northern States. During the months of December, January, February, March, and April, the lower portions of the Southern States, and their seaports, are extremely healthy.[6]

It is truly astonishing how limited the seat of yellow fever is, and how securely a stranger may live quite in its vicinity if he does not enter the infected circle. La Roche[7] says that the immunity is complete in towns, at short distances from the spot where it is raging. In the pure air of the country it never occurs, however close the intercourse with an infected city; and Drake[8] says, "yellow fever is essentially a disease of towns and cities—an epidemic invasion of the country is unknown." The little town of Guanobacoa, within a few miles of Havana, and with which it is in constant communication, is said never to have had a case of the epidemic; and even in the nearest country-houses around Havana and Casa Blanca, strangers are perfectly safe while the disease is raging in the towns: this exemption is confirmed in the history of the disease at New Orleans, Charleston, Vera Cruz, Matanzas, St Jago de Cuba, &c.[9] Instances of exemption, even in considerable towns, occur where most unexpected. The town of Cardenas in Cuba, with a population of 3000, built in a marsh on the north coast of the island, and nearly surrounded by swamps, has never had a single case of yellow fever. Trinidad, in Cuba, has only been subject to the epidemic since its population amounted to 5000; here, and at Puerto Principe, it appears only at intervals of many years. Matanzas has no marsh, but is situated on nearly dry rock: so long as it was a small place, it had no yellow fever, but now that it has a population of 17,000, has a large trade, and is surrounded by vegetation, it has yellow fever at intervals. New Orleans, although built on piles in a swampy site, has sometimes an interval of exemption during four or five years consecutively; such is also the case with Charleston, and Savannah is seldom visited by the epidemic. In the West Indies the greatest mortality occurs among poor Spaniards from the Canary Islands, Germans and Irish who have no means of comfort or medical aid.[10] In Havana, sailors are the greatest sufferers, partly from exposure, hard work, and irregular living. Ships which arrive in ballast, and lie long in harbour, are generally the most healthy: coal and sugar laden ships are the least so. In the period of life between 14 and 25 it is calculated that the cases of yellow fever are twice as numerous as at any other age. From 25 to 40 they are still frequent—beyond 40, cases are of rare occurrence; children under 15 are almost exempt: and females are, in proportion, less frequently attacked, and escape more easily than men.

Intermittent Fever, or Ague.—This, the specifically purest form of malarial disease, is an endemic of all warm climates. It has its base within the tropics, and extends northwards till it is arrested by decreasing temperature. Local malaria is the first and most necessary condition of the endemic and epidemic form of the disease, and always exists where the malady prevails, although the peculiar state of the climate and soil may not be clearly ascertained. Intermittents are very prevalent in the West Indies, and in the interior valleys of North America, but are almost unknown in Nova Scotia and the New England States on the Atlantic seaboard. In Europe, ague is endemic on the coast of the Gulf of Bothnia, beyond lat. 62° north. In the interior valley of North America, intermittent fever[11] is the prevailing malady. From its occurring constantly within the tropics, but ceasing far south of the polar circle, it appears that a high temperature is a condition necessary to its production, but this can only be considered as an exciting cause. It is found that a summer temperature of 60° is necessary to the production of the fever, and that it will not prevail as an epidemic where the temperature is below 65° It therefore occurs in winter at places where the season has a mean temperature of 60° or upwards, as at Vera Cruz, Tampico, Havana, &c.; but at New Orleans, and generally under the 30th parallel, where the mean winter temperature is under 50°, the fever is suspended. At New Orleans the necessary heat exists for 9 months of the year—March to November; at St Louis, 5 months—May to September; at Montreal, 4, and Quebec, 3 months. A continuance of more than 2 months of a heat equal to 60° is necessary to its development; hence it prevails more in October than April, though their mean temperatures are nearly the same, and its greatest prevalence in every latitude is generally some weeks after the hottest months of the year. It is rarely directly fatal, but frequently results in liver disease and dropsy. The western area of the disease is limited in America on the east by the range of the Appalachian Mountains, into the very gorges of which it ascends, by the valleys which penetrate their flanks; while that of the seaboard extends inland to the eastern base of the same range. South of lat. 33°,[12] where this barrier terminates, its eastern limit is the Atlantic Ocean. On the south-west its boundaries are the Cordilleras of Mexico and the southern Rocky Mountains. It is almost unknown 300 miles beyond the western boundary of the States of Missouri and Iowa, and above lat. 37° north. On the north it ceases to prevail as an epidemic at lat. 44°, and it does not occur even sporadically at lat 47°.[13] In Western Europe its limits include Scotland, and on the Continent it extends to the mouth of the Angermann River, lat. 62° 40′, in Sweden. Farther eastward it sinks to a lower latitude, and in Central Asia it appears not to extend beyond lat. 55° or 57° north, forming a curve nearly coinciding with the isotherm of 41°. To the south of this, from lat. 54° to 40°, at the level of the sea, on the coasts and river-banks, it constitutes one of the most prevalent diseases. On the shores of the North Sea it causes a mortality of 1 in 20, and even 1 in 14.[14] On the northern boundary it appears only in its more simple form during summer and autumn. Between lat. 55° and 40° it occurs usually in spring as tertian, and in autumn as quartan ague. It is prevalent on the Lido shores and in the islands of the Gulf of Venice, but does not enter the city. It is periodical at Rome. Elevation above the level of the sea has a very marked influence on the occurrence of intermittent fever; thus while it ravages the *tierra caliente* of Mexico, near the level of the sea, it is almost unknown in and around the city of Mexico, 7450 feet above that level, although both places are in the same latitude. The inhabitants of the Appalachian Mountains, at an elevation of about 3000 feet, are almost exempt, while those who inhabit the valleys, under the same parallels, are affected. Farther north, at an elevation of 1500 feet, at the sources of the Alleghany and Genessee rivers, the disease is almost unknown, while on the low shores of Lake Ontario, directly north, it is prevalent. In lat. 41° it is prevalent at 900 feet above the level of the sea. It also prevails at lat. 41°.30 north, at 1100 feet in elevation, all along the rivers and ponds in the Cuyahoga Basin. The constantly increasing elevation of the desert to the west of the Mississippi, and the increasing dryness of the plains, are probably the chief causes of the disappearance of the fever, under the same parallels in which it prevails on the banks of that river.[15] In Europe, in lat. 52° north, at Cassel, it rises little more than 400 feet above the sea. One degree farther south it occurs every year at an elevation of 600 or 700 feet, near Berka on the Werra; but at 900 feet it comes only once in 10 years in isolated cases. In lat. 47°, at Grätz, 1200 feet above the sea, it is endemic; it is sometimes epidemic at Stanz in Switzerland, 1700 feet high; and it is prevalent on the plateau of Castile, 2300 feet high. In Peru, ague is observed at an elevation of 10,000 or 12,000 feet above the sea, and according to Tschudi, it occurs there in dry and barren regions. In Iceland no native is attacked by ague, and strangers suffering from it soon recover: it is unknown in Tasmania.[16]

The geological formation which appears to be favourable for the development of the malady is indicated by Dr Drake,[17] who says of North America, "the whole southern portion of the cretaceous formation is infested with autumnal fever, beyond perhaps any other portion of the Great Valley;" and again, "like the cretaceous formation, the tertiary region is subject to autumnal fever of a violent character." It has been observed that this fever occurs everywhere in the same geological formation, and in its extension seeks a similar kind of soil. Bierbaum[18] instances the provinces of Alentejo and Algarve in Portugal, where intermittents and remittents prevail, as being similar to South Carolina and some portions of the West Indies. Ague is common among the natives of the Netherlands; it is endemic from the Scheldt to the mouth of the Meuse. At Walcheren in 1809, two-thirds of the British army were seized with ague, and more than 1000 died of the disease within the last four weeks of their encampment there.

At Bordeaux, ague is endemic in spring and autumn. Here, when the pools at the west end were drained in 1805, an epidemic ague broke out and seized 12,000 men, of whom 3000 died in five months.

The influence of sudden atmospheric changes in the production of this disease was exhibited at Landau, where Pauli[19] observed, that on one occasion, when the barometer fell 18″ in 24 hours, 32 individuals were seized with ague within five days.

The decrease of autumnal fevers with the decrease of temperature is strikingly exhibited in the tables furnished at twenty-six military posts between the Gulf of Mexico and Lake Superior.[20] In latitude 24° 33′ north, at Key West, the total number of attacks was—intermittent fevers, 179; remittent, 11; total of the year, 190; while at Fort Brady, latitude 46° 39′ north, the number of cases of intermittent fever was 41, and of remittent 3; total, 41. At Havana it rages epidemically from April to December, and sporadically throughout the rest of the year. The space between latitude 33° and 34° north is traversed by the Cumberland Mountain, a part of the Appalachian chain, forming a rampart more than 1000 feet in height. This constitutes a climatic limitation to plants, both indigenous and cultivated. In every fertile and well-peopled part of the country south of this rampart, the diseases have a more southern character than on the north, in which direction the tables referred to show a decided and gradual decrease. At Toronto both intermittent and remittent fevers prevail every year, but they are more severe in some years than in others. Simple ague is most common, and intermittents are rare. At London and at Fort Malden, Canada-West, autumnal fever still prevails. Intermittent fever is especially a disease of newly-peopled countries, and when it disappears it is because the topographical conditions on which it has depended have been removed. The influence of settlement, cultivation, and town building, is always found beneficial in banishing or mitigating autumnal fever. The prairies, being marshy, are liable to autumnal fever. Open prairie lands are more healthy than the vicinity of woodlands, probably owing to the greater moisture of the latter. The breaking-up of prairie-land induces fever, but sometimes it does not appear till two and three years after the arrival of the first settlers.

Cholera.—Diseases with choleraic symptoms are observed every year, and at all seasons, in the torrid zone, but most frequently and characteristically in the East Indies, where Asiatic cholera appears to be to the Ganges delta that which the yellow fever is to the delta of the Mississippi, or the plague to the delta of the Nile. Cholera, known from time immemorial, and described in Sanscrit works as an endemic climatic disease, limited to the place of its birth, the delta of the Ganges and the shores of India, was first observed as an epidemic in Bengal, in the month of May 1817; thence it spread first north-west to Mirzapore, next south and south-west, and then continuously in a direction contrary to the monsoons; afterwards it extended in all directions, so that within fifteen months it passed through the whole of India to Bombay. It was influenced in its attacks by the state of the weather, the position of a place, and the means of resistance. In summer it was always more severe than in winter, partly from the greater agglomeration of men in the former season. It was carried by vessels to the great seaports, to the Mauritius, Reunion (Bourbon), &c., where it raged among the ships' crews. At the same time it extended into the interior of the continents, step by step, following the movements of troops and the routes of caravans in all directions. Having gained the great trading cities and fortified towns, it started from them as fresh centres, till it overspread all Asia from Aleppo and Bagdad to Pekin. Thence it reached Ceylon, the Philippines, Moluccas, and Sunda Islands. In the East its victims were countless. At Muscat in Arabia, and its vicinity, for example, more than 125,000 persons perished. The great movements of troops occasioned by the wars of the British with the Indian tribes,—of the latter with Persia, of Persia with Russia, and of Russia with Poland, brought the disease systematically into Europe; and it is calculated that in the Russo-Turkish campaign, cholera was, to both armies, ten times more destructive than the bayonet or the bullet. At the end of that war it was expected that the disease would be arrested by the removal of the troops from infected districts, and by the approach of winter, but it was found necessary to convey some Russian troops from Persia and Turkey to Poland, and thus cholera reached the banks of the Vistula. The Austrian and Prussian quarantine systems were useless, and so it spread from St Petersburg to Odessa, by ships throughout Europe, the whole of which was visited by the epidemic, except such countries as Saxony, some of the regions of middle Germany, and others inclosed by mountains, or where little commercial intercourse is carried on. From Europe cholera speedily crossed the Atlantic with the great tide of emigration towards the United States: here it showed itself in its most virulent form, especially in the ports where emigrants landed, but at first it did not extend much into the interior. The first ships with cholera patients on board arrived at New York and Quebec in 1832. At New York a kind of quarantine was kept up, and many died in the hospitals. In Canada, as in Europe, none was attempted, and it spread through the larger towns, and along the commercial routes to the States of the Union. Chicago, on the south coast of Lake Michigan, the chief port for Canadian emigrants, was attacked first, and most severely. The next point whence it spread through the States was New Orleans, to which it was carried by ships from New York, shortly after its arrival there. At New Orleans from 80,000 to 100,000 emigrants arrive annually from Europe, and there is no quarantine. Food for the disease was supplied by the arrival almost daily of hundreds of new emigrants, of whom often thirty died in one vessel on the voyage from England, Germany, or France. It ravaged Lafayetteville, a suburb of New Orleans inhabited chiefly by Germans and Irish, and was carried quickly by steamers to Louisville and Cincinnati on the Ohio, both, but especially the latter, chief landing-places for emigrants. Here the mortality was frightful, greatly owing to a kind of fatalism which led the Germans and Irish to believe that it was useless to attempt precaution or remedy, farther than by wearing amulets, and confining their diet to herrings and cold water. From Cincinnati the disease extended up the Ohio to Pittsburg, and spread thence to New York, Philadelphia, and Baltimore, where, fortunately, it was arrested by the sea. At the same time it was carried by steamers to Albany on Hudson Bay, where it was very severe. From New York it spread little at first, and while it extended from Europe to New Orleans, and thence to St Louis, Louisville, Cincinnati, and New York, numerous cities which lie between, on the Mississippi and the Ohio, remained either altogether free, or were only overtaken long after the outbreak of the disease in places more than a thousand miles to the north and east of them. In the vicinities of great cities it often did not appear till after it had travelled to places many hundred miles distant. It passed from New Orleans to Texas before it showed itself in the vicinity of the city, and from St Louis it was conveyed by travellers to California, among the Indians, to Independence and Fort Leavenworth on the Missouri, and thence west to Fort Laramie, near the Rocky Mountains, and all this in less time than it took to reach Belleville, within a short distance of St Louis. The whole of the southern States of the Union, with the exception of some of the cities on the Ohio, the Cumberland and Red Rivers, or large ports, as Baltimore, almost entirely escaped the cholera. At the ports of Galveston and Lavaca in Texas, where troops arrived from New Orleans, it first appeared in 1848; hence it accompanied the gold-diggers into the interior, to Austin. Shortly after its appearance in Galveston, it was conveyed by ships from New Orleans to Corpus Christi and Brazos St Jago, at the mouth of the Rio Grande, and accompanied the caravans and steamers along that river.

Matamoras was next visited, in summer, and thence, extending still westward, it attained the height of 5000 feet above the sea at Chihuahua, and a still greater elevation in the district of Paso del Norte on the Rio Grande. In the former city, from ignorance of its treatment, it carried off almost every one who was seized, amounting to 60, 70, and even 107 in one day. The States of Ohio, Illinois, and Missouri, suffered most of the whole Union, not only because the chief emigrant ports are situated in them, but because they are traversed by the principal navigable rivers. The most fatal places were in Ohio, the district between Sandusky and Cincinnati; in Illinois, the vicinity of Belleville, the towns on the Mississippi, on the Illinois, the canals, and Lake Michigan; and in Missouri, St Louis and its vicinity, the principal towns on the Missouri, and the routes leading to California. The frequent appearance of cholera along the courses of rivers led at first to the hypothesis, that the disease had a peculiar affinity for water, but the fact was overlooked, that great cities, necessarily the centre of epidemic virulence, are mostly situated on navigable streams; and the triumphant march of the cholera-plague along the caravan-routes in Asia and America, where no water was met with for many days in succession, evinced the fallacy of the opinion. This great epidemic spanned the entire globe,—unlike the yellow fever, it was not confined to a certain elevation above the earth's surface, but, leaving the lower stratum of the atmosphere, it followed its victims to the summits of great elevations,—as in the table-land of Malwa, the villages of which are situated 2500 feet above the level of the sea. In 1818 it appeared at Catmandoo in Nepaul, at the foot of the Himalayas, nearly 5000 feet above the sea; and in 1822, and again in 1852, it raged with great violence at Erzeroum, 6100 feet above the sea. Yet it appears that difference of level has a certain influence on the frequency and virulence of the disease. In the higher quarters of Paris, with an elevation of 56 feet above the river, the deaths were at the rate of 18.55 per 1000, while in the lower quarters, 9 or 10 feet above the Seine, the deaths were 23.00 per 1000.[21] In London the deaths were nearly in the inverse ratio of the elevation of the ground: under 20 feet above the Thames the proportion was 102 in 10,000; from 20 to 40 feet, 65 in 10,000; from 40 to 60 feet, 34 in 10,000; and from 60 to 80 feet, the mortality was 27 in 10,000; 80 to 100 feet, 22 in 10,000; at 350 feet, only 8 in 10,000.[1] In a single year England lost, by the visitation of cholera, 70,000 individuals, of whom 30,000 were adults, being 10,000 more men than fell in battle in the wars between 1800 and 1815.

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[1] Report of British Army, p. 43. The author remarks that while a height of 600 or 700 feet does not secure a healthy situation, yet it is proved beyond a doubt that, at an elevation of 2000 or 2500 feet, they (the troops) are likely to be wholly exempt from that disease, or to encounter it in a very modified form.

[2] La Roche, vol. i. p. 118. Dr Drake (Diseases of the Internal Valley of North America, vol. ii. p. 188) says that, in the Mississippi Valley, its highest point is Memphis, about 400 feet above the sea, and here it only appeared once. According to Humboldt, the farm of the Encero (928 metres), 3045 feet above the sea, forms the upper limit of the Vomito—(Nouvelle Espagne),—and the disease almost never extends beyond the ridge of mountains that separate La Guayra from the valley of Caraccas. "Supposing the fever to have really prevailed at that elevation, we may assume this as the altitudinal point, beyond which, whatever be the high temperature and the fever proclivities of the country generally, individuals are secure against an incursion of the disease. They may carry it, but it will never originate, and certainly never be propagated there."—La Roche, vol. i. p. 118.

[3] In the high latitudes of America also, the danger from the disease, and the number liable to its attacks, are diminished. Thus Walsh reports that of 55 soldiers seized with yellow fever at Quebec in 1805, only 6 perished.

[4] At New Orleans, Savannah, and Charleston, the heat in spring, summer, and the beginning of autumn, is as great as at the islands of San Domingo and Cuba, and is more insupportable from the absence of the sea-breezes. New Orleans, Mobile, Savannah, and Charleston, unite in a high degree the three principal causes of this fever, especially the first, which has a dense population of 145,000. The soil on which it is built is so permeable that water is found at a depth of 2 or 3 feet below the surface. The fever often breaks out here with great violence in the month of June, a fortnight sooner than at Savannah, on account of its more southern latitude and its more inland situation, which deprives it of the cooling sea-breezes. An early season develops the disease at the several ports, in some years a week or two sooner than in others, while a late season often suspends it or insures its entire absence. For the same reason—lowness of temperature—it never appears in winter.

[5] Michaux, Mem. sur la Fievre Jaune.

[6] The effect of situation, combined with temperature, is well exemplified in Philadelphia, the different yellow-fever epidemics in which are recorded, from its first appearance in 1699 to 1853.—(La Roche.) The city is situated between the rivers Delaware and Schuylkill, 60 miles direct from the mouth of the former, in the Atlantic, on a modern tertiary formation, consisting of sand and gravel, mostly overlaid with a thick stratum of clay, the whole resting on a primitive basis from 40 to 50 feet below the surface. The climate is extreme; mean temperature 53°, summer 96°, and sometimes 100° Fahr.; winter, from 0° to 3° or 7°—presenting a difference between the extremes of summer and winter of about 100° Fahr. Mean elevation of the barometer 30°, with small variation. Rain-fall, mean of 44 years, 38 inches. Thus, while the winters are almost Siberian, the summers are truly tropical, and capable, when combined with other causes, of giving rise to diseases of hot climates. Philadelphia is generally healthy as compared with other cities; its streets are wide, and the houses of modern construction, with the exception of Water Street, which runs along and under the original bank of the Delaware, from one extremity of the city to the other. Many of the houses in that street, being built against elevated ground, are damp and confined. Here the first cases of yellow fever invariably appear, in the most aggravated form; and hence, if the weather continues hot and humid, the pestilence penetrates to the successive lines of streets at intervals of some days, and with decreasing severity as it recedes from the river. The progress of the disease towards the interior of the city is always suspended by a rain which lasts for several days, especially if accompanied by a north wind. The yellow fever first appeared at Philadelphia in 1699, and again in 1741, 1747, 1759 (slightly), 1762, 1793, 1794, 1797, 1798, 1799, 1802, 1803, 1805, 1820, and 1853. The first epidemic was as fatal as any that have occurred since; several of those intervening were milder, till 1793, the mortality from which is estimated at 1 in 10 to 1 in 12 of the population, which at that time was between 40,000 and 50,000; the number attacked is estimated at 11,000, and the number of deaths upwards of 4000; 2728 houses were closed, and more than 12,000 of the inhabitants left the city. It was equally severe in 1798. It showed itself only sporadically in 1800 and 1801. In the former year it appeared simultaneously in Spain; and its appearance in 1805 was preceded by its breaking out in 1804 at Leghorn, Gibraltar, &c. From 1820 the disease disappeared from Philadelphia for a period of 33 years, till 1853, when it continued from 19th July to 7th October. In all these instances the epidemic appeared during the greatest heat, and departed on the approach of cold weather. It was uniformly limited to the precincts of the city, extending little, if at all, into the country.

[7] Vol. i. p. 333.

[8] Vol. ii. p. 185.

[9] See Jürg, Tropenklima, p. 41.

[10] The chief victims at New Orleans are emigrants—poor Germans and Irish—who, ignorant of the danger they incur, embark at such a season as to land them there in *summer* and *autumn*, as well as winter and spring.

[11] In different parts of North America this malady is known under the names, autumnal, bilious, intermittent, remittent, marsh fever, ague, &c.—Dr Drake, vol. i. p. 703.

[12] The greatest mortality in the south is occasioned by malignant intermittents, but the sickly season extends only from July to November; and below this parallel (lat. 33°) "the inhabitants enjoy more uninterrupted health for eight months in the year than in any other part of the valley; and hence it was not without reason that the distinguished Professor Caldwell attempted to show that, taking the year round, New Orleans was the healthiest city on the continent."—Drake, vol. ii. p. 136.

[13] In North America it occurs much more frequently in the country than in towns, and is as prevalent and violent in places remote from, as those on the banks of the Mississippi. It occurs sporadically every year, and is annually epidemic in some part of its region: its usual course is from three to four months.

[14] Fuchs, Medizin. Geog. Berlin, 1853.

[15] In lat. 42° north, the topographical conditions which originate autumnal fever are nearly overcome by a mean altitude of 1400 feet; but among the mountains of Virginia, at an elevation of 1800 feet, Professor Rogers saw many cases of intermittent fever, which may be ascribed to difference of latitude, being 4° farther south. This indicates that in lat. 37° or 38° north, an elevation of 1800 or 2000 feet is not sufficient to arrest autumnal fever in fertile localities abounding in organic matter. It still prevails at Fort Wayne, lat. 40° north, 753 feet above the level of the sea. Neither intermittent nor remittent fever has ever originated in the vicinity of marshes between lat. 47° and 49° north—*i. e.*, from Quebec to the Gulf of St Lawrence—this being beyond the geographical limits of autumnal fever, which is also unknown in the valley of the Saskatchewan, in the Hudson Bay basin.

[16] From the middle of the fifteenth century till comparatively recent times, intermittent fever visited England periodically, and spread universally. It spared no class of the people, and James I. and Oliver Cromwell both fell victims to it; but although it still exists in marshy districts, it is all but unknown in London.

[17] Vol. i. p. 177.

[18] Das Malaria-Siechthum: Wesel, 1853.

[19] Med. Annalen, II 4.

[20] Drake, vol. i. 796.

[21] Rapport par M. Mille, ingenieurs des ponts et chaussées, Ann. d'Hyg., pub. 1855.

The *Plague* has its endemic seat on the eastern shores of the Mediterranean, where it has been known to exist since the middle of the sixth century. Periset considers the Nile delta as the peculiar developing-place of the plague. The causes to which it is attributed are, the great heat, the overflowing of the river, the want of cleanliness in the people, and the exposure of the dead in and near their dwellings. It may be considered as occupying permanently a portion of the Old World, extending between the parallels of latitude 29° and 42° north; and while it is thus permanent in some places, it appears more or less frequently in others. Its term of periodicity was reckoned to be, for Constantinople 9 years, Egypt 5, Aleppo 10, Antioch 15, and Cadiz 43 years. In Sydenham's time it was said to ravage England every 40 years. It has not appeared in Scotland since the reign of Charles II., although it remained a few years longer in England. It seldom extends to the southward beyond Siout in the valley of the Nile, or Jiddah on the Red Sea. In Asia it prevails chiefly on the coasts of Syria, and a portion of the shores of Asia Minor, where it sometimes ascends the river valleys. In Europe it is endemic only on a part of the eastern coast of Turkey. In 1816 it was very destructive in the Ottoman empire, and extended into Austria, Italy, and Sardinia, and it was at Moscow and Marseilles last century. In 1841 it raged in Syria and at Erzeroum with great violence. It has never yet appeared in the southern hemisphere, nor in America.

Like the yellow fever, the plague appears to be limited to the lower portions of the earth's surface, the more elevated situations being usually exempt from its scourge. When it is ravaging the lower quarters of Constantinople, the inhabitants of the higher portions of the seven hills on which the city is built often escape altogether; and Brayer mentions a village situated on mount Alem Dagh, at an elevation of about 1600 feet above the sea, where it was never known to appear, and which was resorted to as a place of refuge for the citizens; and there is a place in Malta hitherto inaccessible to the disease, and on this account called *Saf* (pure).[2] It is recorded by the French physicians, that during their occupation of Cairo, the plague never reached the citadel of that city; and Clot Bey states that it, as well as the village of Loumeldik, situated at a considerable elevation, was spared during the epidemic of 1835. The nature of the soil has much to do with the development of this disease. As an argillaceous soil is most favourable for the development of malarial fevers, so it is a characteristic of the localities where the plague is endemic. Puguet says that it rarely appears in deserts or sandy soils, but that it immediately breaks out on the rupture of the dyke which confines Lake Madieh; and Clot Bey observes that, during the great epidemic plague of 1835, the Egyptian regiments encamped in the desert escaped almost entirely, notwithstanding the maintenance of communication with the capital and other places where it committed the greatest ravages. Ghizeh, which is placed on the banks of the Nile, and completely inundated by the river, is much more frequently infected than Cairo. Salahieh does not receive its contribution of Nile water till long after the capital, and it is not visited by the plague till after a similar interval. According to Gaetani Bey,[3] the plague is arrested at Assouan, on the borders of Nubia, on account of the difference of situation, heat, dryness, and the nature of the soil. It breaks out readily in localities where the water is stagnant from the absence or neglect of canals; hence Bassorah and Bagdad, formerly safe, from the cautious administration of the canals, are now the theatre of this scourge.

When the plague visits Constantinople, it appears usually between the 1st and 20th of July, and decreases on the approach of winter; while in Egypt it commences in winter, and disappears at the end of June.[4]

Typhus.—This form of fever, which occurs frequently as an epidemic, appears to belong exclusively to the north temperate zone, and even here it avoids extreme latitudes.[5] It is scarcely ever mentioned by medical voyagers in hot countries.[6] As yellow and intermittent fevers occur in low latitudes, near the level of the sea, so typhoid fevers have their base line in a high latitude, and at a greater elevation. Yellow and intermittent fevers decrease from south to north, but typhus, on the contrary, decreases from north to south. In America, typhoid fevers diminish in frequency beyond the parallel of 45° north. Typhus does not appear among the fur stations of the Hudson Bay Company between the parallels of 48° and 58° north; and no mention is made of its occurrence among the crews of the Arctic voyagers nor among the Esquimaux, who live in close unventilated snow-huts; neither has it been observed by Ermann and Wrangell among the inhabitants of Siberia.[7] Typhus has, therefore, a northern as well as a southern limit. In Western Europe it prevails between the parallels of 44° and 60° north, or between the isothermal curves of 48° and 52°; and in North America between the parallels of 32° and 43°. In places where the mean annual temperature rises above 62°, or falls below 40°, it prevails but little in either continent. The geographical and climatal limits of typhus in Europe and America will be found to correspond nearly with those of the glutinous cerealiæ and the potato.[8] It decreases with elevation; and to this cause has been attributed its absence in the hospital of Madrid, 1995 feet above the sea. It occurs in every season, but is most prevalent in autumn and winter. According to the army reports,[9] typhus appears to be three times more prevalent in Lower than in Upper Canada. As intermittent fever is a disease of new, so typhus is of old countries; where the soil has been longest cultivated, typhoid fevers are most prevalent. The early settlement of the lands along the estuary of the St Lawrence is probably the chief cause of the remarkable prevalence of typhus, and the absence of intermittent fevers there.[10]

During 1847, the so-called famine-typhus prevailed over a great portion of Europe. In Poland, especially in Galicia, and in Silesia, it was currently reported that 40,000 of the people were in a state of starvation.[11] In Ireland it carried off 100,000 of the population. It commenced in Cork and Liverpool, where thousands of emigrants were assembled on their way to America. The wellbeing of the great trading towns prevented the spread of the disease on shore, but the good effects of sufficient food on ship-board were counteracted by the foul air of the crowded space between decks, and a fatal and highly contagious form of typhus was engendered among the passengers, which, in spite of quarantine regulations, they conveyed into the principal ports of Canada and the United States, and thence it spread to the interior of the country. In Quebec, Montreal, New York, and New Orleans, not only the emigrants, but also the inhabitants, fell in thousands before the scourge. In New Orleans the "ship's fever," as it was called, was more dreaded than the yellow fever. The approach of winter, and a strict enforcement of quarantine laws, put a period to the epidemic in 1848.

Phthisis.—Tubercular consumption cannot be said to be a disease peculiar to any one portion of the globe, or to be dependent on climate in any appreciable degree, unless it can be shown that it does not prevail in the excessive climates of the north. It originates in all latitudes from the equator, where the mean temperature is 80°, with slight variations, to the higher portion of the temperate zone, where the mean temperature is 40°, with sudden and violent changes. The opinion long entertained, that it is peculiar to cold and humid climates, is founded in error. Far from this being the case, the tables of mortality of the army and navy of this and other countries, as well as those of the civil population, warrant the conclusion that consumption is more prevalent in tropical than in temperate countries. Consumption is rare in the Arctic regions,[12] in Siberia, Iceland, the Faroe islands, the Orkneys, Shetlands, and Hebrides. And in confirmation of the opinion that it decreases with the decrease of temperature, Fuchs shows, from extensive data, that in northern Europe it is most prevalent at the level of the sea, and that it decreases with increase of elevation to a certain point. At Marseilles, on the seaboard, the mortality from this cause is 25 per cent. At Oldenburg, 80 feet above the sea, it is 30 per cent; at Hamburg, 48 feet above the sea, it is 23 per cent; while at Eschwege, 496 feet above the sea, it is only 12; and at Brotterode, 1800 feet above the sea, 0.9 per cent. It is calculated that in the temperate zone, within which nearly all the civilised inhabitants of the globe are located, at least one-tenth of the population die of this malady. It is uniformly more fatal in cities than in the country: in England the excess in cities is equal to 25 per cent. The greatest mortality occurs from the age of 15 to 30: taking the sexes together, it destroys one-half of all who die from every kind of disease in Massachusetts, between these ages.[13]

Cretinism and Goitre.—These two forms of disease frequently occur together, but are by no means identical. Wherever cretinism occurs, goitre is generally present, but in many places where goitre prevails, not one cretin is to be found. Although only recently brought into notice, cretinism was known and described early in the 17th century. Though sometimes sporadic, it is chiefly an endemic disease, supposed to originate in certain conditions of soil, air, and water, and occurring in deep narrow valleys of Alpine regions, as well as in low, flat, marshy districts: in the former it is termed *Cretinismus alpinus*, and in the latter, *Cretinismus campestris*. This dreadful malady, which has been termed the "Leprosy of the age," is thus defined by the Sardinian commissioners:[14]—"Cretinism is a degeneration of the human species, which manifests itself in certain parts of the globe, and is characterised by a greater or less degree of idiocy, associated with a vitiated state of the body." They divide the sufferers into the complete cretins, simply vegetating masses, devoid even of instinct; the half cretins, who can articulate some words, can make themselves understood by gesticulations, and can perform some mechanical labour; and the cretinous, who are possessed of understanding and will. Cretinism differs from simple idiocy in that the body of an idiot is often well formed, while the cretin is an idiot whose physical formation has suffered a general degradation.[15] In the complete idiot the faculties are radically extinct, or exist only in a rudimentary state, whilst in the cretin they are oppressed and overpowered by the disease, but not abolished. The cause of this disease has been sought for in all the natural elements, by turns, without any satisfactory result. In the province of Kumaon in India, goitre is so prevalent that one-half of the population is afflicted by it. A large proportion of these cases occur among the population who live on the limestone formation; while goitre is almost unknown on the granite, gneiss, and sandstone formations. One in every 3 of the population on the limestone formation was afflicted with goitre, and 1 in 12 was a cretin. On the mica, hornblende, and sandstone formations, neither goitre nor cretinism was seen.[16] Hence the disease is produced, according to some authors, by the use of water impregnated with lime. Others refer it to exhalations from the soil, electricity, drought, &c. Again, a specific malaria is contended for as the only way to account for the appearance of the malady in one part of a valley, a village, or even a single house, while in the immediate vicinity it has never appeared. In Europe, cretinism occurs in the valleys of the Pyrenees, the Alps, Apennines, the Schwarzwald, the Rauhe Alp, Thuringer Wald, the Harz, the Erz, and the Riesen-gebirge, in the Carpathians (Neusohl in Hungary), among the mountains of Styria, the Vosges Mountains in France, in the West of England, in Wales, in Denmark, and the low-lands of Rhenish Prussia; and it has recently been observed in Berlin, Paris, Vienna, and other populous places. It prevails in the mountainous countries of Upper Asia, in the Cordilleras of South America, and in the northern part of North America.

Saussure was the first to remark that cretinism is limited to a certain height above the sea. This he fixed at 1000 metres (3280 feet) in Switzerland; and numerous observations have since confirmed the general accuracy of his statement, which is exemplified in the total absence of cretins at Ursern, in the Canton Uri, 4600 feet above the sea, where, in 1847, not one was found in a population of 4000. In ascending the St Bernard from Martigny, the disease decreases in proportion as the surface rises, till, at the highest village, St Pierre, no trace of it is to be found. The Sardinian Commission dispute this statement, and account for the number of cases occurring under 3200 feet from the circumstance that the cultivated soil and the habitations of men are found under this level; and they quote many villages in Savoy much higher than this which are peopled with cretins. But all observation shows that this limit changes as in the case of other diseases, according to geographical position. Thus in Southern Germany it varies from 1400 to 2100 feet; in Würtemberg it is about 2100 feet; in Sardinia, 5300 to 6400 feet; and in the Cordilleras of the Andes, according to Humboldt and Boussingault, 15,000 feet. Exceptional cases occur in Switzerland above the height named, and the Sardinian Commissioners themselves state that the most elevated parts of Upper Savoy are entirely exempt from goitre and cretinism. It is calculated that in Switzerland there are in all 20,000 cretins, and these are very unequally distributed; for while in the Canton Valais there is one cretin in every 25 of the inhabitants, in that of Uri there is 1 in every 83, and in the Canton Glarus only 1 in 375. In 1845 the population of Sardinia was 4,125,740, half of whom occupy the mountainous districts where cretinism is endemic. The number of cretins is stated by the commission at 7084, of whom 5500 were in the provinces of Savoy and Aosta, 1413 in Maurienne, and 2180 in the valley of Aosta.[17]

From the inquiry instituted by the King of Würtemberg, conducted by Dr Rösch,[18] it appears that in a population of 1,726,536 souls, 5000 families were more or less affected by the disease, of whom 1000 were cretinous-deaf, and 144 cretins of the highest degree, destitute even of the appearance of humanity. Baden had, in 1844, 440 cretins, of whom 275 were complete, and 165 half cretins; in 1847 the total number had increased to 490. The official returns of the population of France for 1851 show that 42,382 of the inhabitants were goitrous (not distinguishing cretins), equal to 118 in 100,000 individuals; these were mostly in the departments H. Pyrenees, H. Alpes, Ariége, Vosges, and Puy de Dôme.

The Government of Bavaria instituted an inquiry in 1840, and Professor Virchow reports,[19] that in Lower Franconia alone, in 500,000 of a population, there are at least 200 true cretins. It appears that the disease is most prevalent in the highlands of Bavaria, but statistics are not yet published on the subject.[20] In Upper Austria the disease is so prevalent along the banks of the Danube, that, according to Dr Schausberger, whole families consist entirely of cretins and half-cretins, so that, in villages with a population of 4000 to 5000 souls, not one man is found capable of bearing arms. And the statistical inquiries instituted by the Archduke John show, that in Styria there are 6000 cretins of the highest grade.[21] In Rhenish Prussia, cretinism is endemic in the lower districts. Of this the small island of Niederwörth, below Coblenz, furnishes a remarkable example. Of 750 inhabitants, nearly all are goitrous, and 40 are cretins. The other places where it is most prevalent are the vicinity of the Lacher-see, near Bonn, and the village of Niedermendig, celebrated for its millstones, where there were 22 cretins in a population of 300. In Denmark, Dr Huberts[22] states, that among 2000 idiots there are many true cretins. These are found mostly on the north sides of the valleys, as in the Canton Argovia, in Switzerland.[23] In England, cretinism is endemic in Somersetshire, where the village of Chiselborough, situated in a valley, has 350 inhabitants, the greater part of whom are goitrous, and 24 are cretins.[24] A village in Yorkshire, with 200 inhabitants, has 20 cretins. The Netherlands is remarkably exempt from this form of disease.[25]

Goitre occurs in all quarters of the globe. In Europe it is prevalent in the valleys of the Pyrenees, on the Spanish more frequently than on the French side, where the mountains are more steep; but the plains of Spain, as well as the highest inhabited parts, are free from the disease. It is endemic in all the mountainous countries of middle Europe, from the French coast to the shores of the Black Sea. It also appears sporadically in the plains of middle Europe, at Berlin, St Petersburg, and in other parts of Russia; but the marshy districts of Russia on the North Sea are exempt from goitre. In England it occurs in Warwickshire, Lancashire, Somerset, and Derby; in the latter county it is so prevalent that it is termed the "Derby neck." It is said to occur in Scotland, in the island of Arran and in Peeblesshire.

Its northern limit is in Western Norrland, Sweden, about latitude 63° north. In Asia it occurs in the mountain valleys of the Ural, the Caucasus, the mountains of Lake Baikal in Central Asia, in the Himalayas, and in Sumatra. In Africa goitre has been observed in the Atlas Mountains, and in the mountains of Kong. In North America it is very prevalent: its northern limits appear to be about latitude 58° north, at the sources of the Peace River. It is common on the banks of the Saskatchewan River, in Upper and Lower Canada, in the States of New York and Pennsylvania, and especially on the tributaries of the Ohio, where the Indian women are generally goitrous.[26] In South America it extends to latitude 44° south, in the valleys of the Cordilleras, and also in Brazil. In its prevalence above the level of the sea it closely resembles the distribution of cretinism.

Leprosy.—In its endemic distribution, this malady extends over South America to latitude 30°, excluding, therefore, the southern portion. In North America it occurs in Greenland, and in Europe it is limited to portions of Greece, Norway,[27] Iceland, and Lapland. In Africa it spreads to latitude 20° south; it was frequently observed on the upper Niger, and it prevails over the western and south-eastern parts of Asia, with the adjacent islands. Its greatest intensity corresponds with the belt of maximum heat of the globe. According to Pliny, *lepra nodosa* appeared in Italy and other parts of Europe in the second half of the second century B.C. In consequence of the warlike expeditions of the Saracens and the Crusaders, it became so general, that at the end of the thirteenth century, 19,000 hospitals for lepers were opened in Middle and Western Europe.[28] Here it remained till the fifteenth century, when it invaded Russia, and extended to Iceland and Greenland. Leprosy had, therefore, left its original endemic centre, and spread in a direction from south to north. Afterwards it gradually declined, and is now of comparatively rare occurrence in Europe and North America. The malady is however common at Bahia in Brazil (see p. 119). It is probable that the disease in the Western Hemisphere is the same as that of the East, or a similar malady modified by climate.

Pellagra,[29] *Italian Leprosy, or the Lombardo-Venetian Plague,* is a disease which has baffled all attempts to discover its origin. Its usual course is lunacy, mania, or helpless imbecility, and death. In 1831 official returns showed that 20,000 Milanese—amounting to one-third or one-fourth of all the patients in the Lombardo-Venetian lunatic asylums were attacked by pellagra, and in 1843 the proportion in the hospitals of Brescia had increased to three-fourths of the patients. This loathsome malady is described as being much more deplorable even than cretinism: it sometimes keeps the patient in a hopeless state for ten or fifteen years. It has been ascribed to the use of maize,[30] which forms the principal article of diet to nine-tenths of the Milanese peasantry; but it does not occur in the similar maize-growing districts of Naples, Sardinia, and Sicily, nor even in some districts of Lombardy itself. It appears to be a local disease, and is cured by removal and nourishing animal diet. Some years since the pellagra appeared in France, in the department Gironde, and in Gascony. Its limits of greatest intensity are between latitude 43° and 46° in Upper Italy, the south of France, and the north of Spain.

THE ARMY.

Since a great part of our information regarding diseases incidental to tropical countries is derived from tables of the sickness and mortality of European soldiers and sailors, it becomes important to inquire in how far the morbid phenomena therein exhibited may be due to other causes than the direct effects of climate. It has been usual to attribute a large proportion of the mortality among troops to the use or abuse of intoxicating beverages. Thus Forey[31] says, in reference to the troops in America—"The vice of intemperance is the most prolific source of disease and death;" and again, "nine-tenths of the mortality at the salubrious posts along the coast of New England has its origin in inebriating potations." Similar statements constantly occur in the returns of the British army; and hence it is inferred that all stimulating beverages are hurtful in warm climates; but these statements, so injurious to the reputation of the soldier, are, it is believed, greatly exaggerated.[32] The deficiency of nutritious food is a frequent cause of mortality among troops. Most authors agree that the use of invigorating nourishment is a primary condition of successful defence against malarial poison.[33]

Next to food, and perhaps before it, in importance in the development of disease, is the water, often stagnant or corrupted by exposure to the sun, or containing a large amount of salts, with which the soldier is obliged to satisfy his thirst.[34] Besides physical causes, the soldier is subjected to moral influences, such as expatriation, chagrin, and many others, single or combined, which originate or increase derangement of the functions. To these may be added the unhealthy situation, overcrowding, and bad arrangements of the barrack accommodation in tropical countries, and the fatigue and exposure incident to the events of war, of which the returns of the British, French, American, and Prussian armies afford many instances. During the first occupation of Oran, in Algeria, the French army lost 1 soldier in 12, and 1 officer in 54, and this rate continued for several years; but in 1837 harassing expeditions commenced, and the rate of mortality from disease increased to 1 private in 9, and 1 officer in 42. When all was again tranquil, the mortality was reduced to 1 private in 19, and 1 officer in 90.

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[1] Registrar-General's Reports, Journ. Statist. Soc., vol. xv. p. 159.

[2] Boudin, p. 31.

[3] Sulla peste che affiisse l'Egitto l'anno 1835. Napoli, 1841.

[4] The coincidence of the same disease in two different seasons may be explained by the difference in latitude of the two countries, and by the overflowing of the Nile, through which a vast morass is changed into a pond, and the disease is arrested.

[5] Guyon says it has been observed within the torrid zone, but only at an elevation of 7000 or 8000 feet.

[6] Typhoid fevers are not known in Algeria.—(Boudin, p. 20.) La Roche says the true typhus, if carried, will not stay in warm climates.—(Vol. i. p. 289.)

[7] Fuchs, however, affirms that typhus visits Iceland almost every year, and is sometimes epidemic and contagious. (*Medicin. Geog.* p. 23.)

[8] Drake, vol. ii. p. 451.

[9] Tulloch.

[10] Drake, vol. ii. p. 448.

[11] Dr Edward. Jber., Leipzig, 1854.

[12] The Esquimaux inhabit the sea-coasts of the Arctic regions, the mean summer-heat of which is 25°, while in winter the temperature is minus 26°, and for the greater part of the year they live in snow huts; yet consumption is rarely mentioned as occurring among them by any of the observant Arctic voyagers who visited and resided in these rigorous climates, and the voyagers and travellers themselves were equally exempt from this disease. In the period from 1818 to 1833, the sojourn of Europeans there was equal to 1000 men for a year, and yet only two deaths from consumption are recorded, in one of which the disease had commenced before the patient left England. Now, according to authentic tables, seven would have died in Britain or the West Indies from the same disease in the same time. No mention is made of the occurrence of consumption in Siberia by Wrangell or Ermann. From these data Dr Drake (vol. ii. p. 938) concludes that those predisposed to consumption should seek a *cold and dry* climate, a higher rather than a lower latitude; that they should not seek a warmer climate in winter, but a colder in summer; and if living far south, he says, it might be well to remain in the colder climate throughout the winter.—(P. 991.)

[13] In England "it is the cause of nearly half the deaths that occur between the ages of 15 and 35, and during one year it was fatal in 50,594 cases."—(*Reg. Gen. Report*, 1855.)

[14] Rapport de la Commission créé par S. M. le Roi de Sardaigne pour étudier le Crétinisme, Turin, 1848; and Traité du Goître, &c., par M. Niepce, 2 vols. 8vo, Paris, 1852.

[15] Dr Niepce, Traité du Goître et du Cretinisme. Paris, 1851.

[16] Dr M'Clelland, Inquiries in the Prov. of Kumaon.

[17] From a subsequent visit to Sardinia, Dr Guggenbühl thinks the Commission have understated the numbers, and that there must be at least 10,000 cretins in Sardinia.—(Abendberg, S. 40.)

[18] Erlangen; 1844, 8vo.

[19] Phys. Med., Gesellschaft zu Würzburg, Bd. ii., 1851.

[20] Some of the physicians attribute the cause of cretinism to the fanatical opposition of the people against the Church! Dr Stahl, Beob. ü der Cretinismus. Tübingen, 1852.

[21] It is remarked that in the cretinous districts of Styria there are only 95 blind persons in a population of 956,863, while in Hungary one in every 500 of the population is blind.

[22] De Sindssyge S. Danmark, Kjöbenhavn, 1851.

[23] Here vegetation exhibits a different character, the wood on the north side of the mountains being looser and more porous than on the south. Hence Zschokke ascribes the cause of cretinism to the absence or weakness of light; but this can only be one of many causes, for in the valley of Aosta, cretinism is most prevalent on the sunny side.

[24] Dr Guggenbühl, Letter to Lord Ashley, 1851. Dr Blackie mentions a supposed case of cretinism near Edinburgh, and is of opinion that extended inquiry would lead to its detection among the idiot population of Great Britain and America generally.—(*Cretins and Cretinism*, Edinburgh, 1855.)

[25] Long considered incurable, the philanthropic exertions of Dr Guggenbühl have proved that the disease is not only capable of amelioration, but of cure, if the remedy be adopted at a sufficiently early age. His hospital on the Abendberg, near Interlachen, Canton Bern, is situated on an elevation of about 1500 feet above the valley, and 3800 feet above the sea, which is beyond the upper limit of the disease in Switzerland. It was established in 1840, and has already been the means of restoring many victims to society. This benevolent example is being followed by the institution of similar hospitals in several countries of Europe.—(*See* Die Cretinen Heilanstalt auf dem Abend-Berg; Bern, 1853.)

[26] B. S. Barton.

[27] There is a hospital for lepers at Bergen. Leprosy is still common in most parts of Norway, and is rather on the increase.—(Forbes's *Norway and its Glaciers*, 1853.) The statistical returns show that in Norway there were, in 1845, 201 lepers in towns, and 992 in the rural districts; in all, 1193, forming .0084 per cent. of the population.

[28] At this time it was so common in England, that it was made the subject of several legislative enactments.

[29] From *pellis agra*—unhealthy skin.

[30] The cultivation of rice in Europe dates from the close of the thirteenth century, and since that time it has been frequently prohibited in Lombardy on account of its insalubrity.—(Smith *On Italian Irrigation*, 1852.) A frightful pestilence, which devastated the province of Milan in 1630, was attributed to this cause, but the question of the amount of disease due to rice-fields is still in dispute.

[31] Climate of the United States, 1842, pp. 150, 152.

[32] Haspel states his conviction, from a ten years' residence with the French troops in Africa, that not one-tenth part of disease among them arises from this cause. "If," he says, "some soldiers are taken ill after drinking, it is certain that a greater number preserve their health by the use of stimulants in moderation." "Wine," he observes, "is a powerful means of counteracting the effects of marsh effluvia;" and "a certain daily allowance of spirits is necessary to maintain the dispositions of the body against morbific influences." The necessary use of liquors in the camp must not be confounded with excesses in the time of peace; and allowance should be made for exposure to extremes of heat and cold, humid air, and fatigue. Jaquemont says that in India, the central seat of dysentery, cholera, liver disease, and fever, "the English officers who spend half of their time in drinking the strong wines of Spain and Portugal only fall at the rate of 3 per cent;" while the average mortality among the troops is 5.7 per cent. It is related that, during the dysentery epidemic of the Netherlands in 1747, those among the English army who were able to procure spirits or wine escaped the disease. La Roche says, that wine in tropical climates is, in moderation, not only not objectionable, but absolutely required. Drake asserts that soldiers are not more exposed than the poorer classes of every country; and that whatever may be their propensity to intemperance, it is not more indulged in by them than it is by an equal number of the same class of persons out of the army. The melancholy case mentioned in the British Army Returns proves that a life of regularity and pure morals is not sufficient to counterbalance the influence of climate and soil. Of 89 missionaries settled at Sierra Leone from 1804 to 1825, all in the prime of life, 54 died, 14 returned to England in shattered health, 7 in good health, and 14 remained on the coast. Again, a detachment of 108 men (whites) arrived on the Gambia at the end of May 1825, just as the rainy season commenced. Between that date and the 21st September of the same year, there died of remittent fever 74, other diseases 13, total 87; remained alive, 21st September, 21. Owing to the want of accommodation on shore, another detachment of 91 men was, during this period, kept on board the Surrey transport, and, while there, did not lose a man; but at the end of September they were landed, and made up the force to about 112, of whom, between that period and the 21st December, there died of fever 61, other diseases 12, total 73. During this dreadful mortality a detachment of from forty to fifty black soldiers of the 2d West India regiment lost only one man, and had seldom any in hospital.

[33] "Those who are well nourished," says M. Worms (Des Maladies de la Province de Constantine), "pass through, or even sojourn with impunity in, localities where others meet with disease and death. In the army, where soldiers and officers are exposed to the same morbid influences, the average deaths is 1 in 12 of the former to 1 in 54 of the latter. The officers, by proper nourishment and the use of fermented liquors, sustain the vital energy, which has a tendency to fall into inertia, and so escape the effects of the malaria which makes such ravages around them. For the same reason it is remarked, in the statistics of the French army, that the men belonging to the special corps—the artillery and engineers—who are better paid, usually enjoy a satisfactory state of health, while the rest of the army are decimated by fever. The commissioners of inquiry of the British army at Sierra Leone found that the main cause of the fearful mortality from diseases of the digestive organs there—two-fifths of the cases having proved fatal—arose from the use of salt rations, and that, by the substitution of a fresh-meat diet, the mortality from these diseases was reduced to a tenth of its former amount. See also the evidence of Sir A. Halliday, *West Indies*, p. 72.

[34] The returns of the Registrar-general of England, and the statistics of the health of the French army in Africa, furnish numerous examples of the effect of impure water in the production or aggravation of disease.

These circumstances, in great part peculiar to the army, render a comparison between the diseases incident to them and civilians in the same climates impracticable; and even a comparison of the liability to disease among soldiers of different armies is extremely difficult, since not only the difference of age at entry, and the longer or shorter period of service, but also the nationality of the soldiers, must be taken into the account.

On the other hand, many circumstances in an army favour this comparison, as the exclusion of the weak and sickly from all the returns, the same occupations, and a similarity in lodging, dress, and food—circumstances which no civil population can present on so large a scale. In the British possessions, France and America, it is found that the mortality among troops, even when in their own country, greatly exceeds that of the civil population; and that in the infantry the mortality is much greater than in the cavalry and artillery.[1] According to Casper, the soldier and civilian in Prussia stand in precisely the same relation as regards mortality.[2] He states from official statistics, that the mortality in the Prussian army averages only 13 per 1000. In Great Britain the ratio is upwards of 15 per 1000; and Count Morozzo shows that among the infantry in the Sardinian army it amounts to 35 per 1000.

In the Prussian army, while the infantry, as stated, die at the rate of 13 per 1000,[3] among the artillery the ratio is 10, cavalry 9, and the pioneers only 6 per 1000. This proportion holds in the British and French armies. Among the Sardinian troops it is still more striking; for while in the infantry it amounts to 35 per 1000, in the cavalry it is only 18 per 1000. This appears to indicate that the infantry fall faster, because they have to bear the burden of the service alone, while the cavalry and artillery share it with their horses. The influence of climate on the health of the troops is shown in the following Table. The effects of discipline, or of undetected moral causes, are strikingly exhibited in the comparative number of suicides among the different corps. In Britain, of 10,000 men, 8 die annually by their own hands; in Prussia, only 4 in 10,000. In Britain the greatest number of suicides occur among the cavalry; and this is also the case in Prussia; where among the artillery and pioneers the proportion is 2, the infantry 4, and the cavalry 7 in 10,000.

COMPARATIVE STATEMENTS OF THE MORTALITY AMONG THE BRITISH TROOPS SERVING IN DIFFERENT PARTS OF THE EMPIRE.

AVERAGE MORTALITY PER THOUSAND OF WHITE TROOPS ANNUALLY.

COLONIES.	For 20 years ending in 1836.	For 10 years ending in 1846.
New South Wales,	14	11
Windward and Leeward Islands,	$78\frac{5}{10}$	$68\frac{1}{10}$
Jamaica,	$121\frac{3}{10}$	$66\frac{7}{10}$
Gibraltar,	$21\frac{4}{10}$	$10\frac{8}{10}$
Malta,	$16\frac{3}{10}$	$14\frac{7}{10}$
Ionian Islands,	$25\frac{2}{10}$	$15\frac{3}{10}$
Bermudas,	$28\frac{8}{10}$	$29\frac{6}{10}$
Nova Scotia and New Brunswick,	$14\frac{7}{10}$	13
Canada,	$16\frac{1}{10}$	$12\frac{6}{10}$
Newfoundland,	14	$9\frac{1}{10}$
St Helena,	$34\frac{5}{10}$	$15\frac{8}{10}$
Cape of Good Hope,	$13\frac{7}{10}$	13
Mauritius,	$27\frac{4}{10}$	$24\frac{1}{10}$
Ceylon,	$69\frac{8}{10}$	$41\frac{7}{10}$

This Table shows a great saving of life during the last ten years.[4]

In the year 1849, the ratio of mortality among the white troops, in our different colonies, was as follows, showing, in many instances, a great discrepancy with the 10 years average above:—

In Australia, 8; British Guiana, 14.2; Trinidad, 33; Tobago, 98.6; Grenada, 12.3; St Vincent's, 6; Barbadoes, 123.3; St Lucia, 17.4; Dominica, 40.4; Antigua, 10.9; St Kitt's, 19.4; Windward and Leeward combined, 68.4; Jamaica, 48.3; Gibraltar, 8.4; Malta, 30.1; Ionian Islands, 23.1; Bermuda, 8.4; Newfoundland, 10.3; Nova Scotia and New Brunswick, 19.7; Canada, 15.6; St Helena, 8.4; Cape of Good Hope, 13.3; the Mauritius, 14.6; Ceylon, 21.5; Madras, 22.4; Bengal, 61.3; Bombay, 26.6.

Comparing the foregoing mortality with that of the troops in the United Kingdom, the superiority of the Australian climate will be manifest.

AVERAGE MORTALITY PER THOUSAND OF TROOPS EMPLOYED.

UNITED KINGDOM.	For 7 years previous to 1836.	For 10 years ending in 1846.
Household Cavalry,	$14\frac{3}{10}$	$11\frac{1}{10}$
Dragoon Guards and Dragoons,	$14\frac{7}{10}$	$13\frac{3}{10}$
Foot Guards,	$21\frac{5}{10}$	$20\frac{4}{10}$
Regiments of the Line,	$18\frac{1}{10}$	$17\frac{9}{10}$

Among the French troops in Algeria, from 1837 to 1846, the loss was, in proportion to those serving in France, as 77.8 to 19.5, or nearly as 4 to 1. Since the illusion of the supposed power of acclimatisation to abate disease in hot climates has been detected, and the system of rotation, limiting the residence of a body of troops to three years in the same colonial region, has been adopted, a great decrease of mortality has resulted at all the stations. In Gibraltar this decrease was from 22 per 1000 before, to 12 per 1000 after the change of system. For several years the mortality among medical men on the west coast of Africa was 78 per cent annually, and no one could be got to supply the vacancies; but when the time of residence was limited to one year, the mortality immediately fell to 25 per cent.

It is a common prejudice, even in the army, that the number killed in battle exceeds the mortality from disease; but this is so far from being the case, that the loss of the French army in Egypt, at the beginning of the present century, was—

Killed in battle,	3614
Mortally wounded,	854
Killed by various accidents,	290
Died by disease,	4157
Total,	8915

The British army in Spain lost in 41 months—January 1811 to May 1814—on a *force of* 61,511 men, 24,930 by disease, and only 8,889 by the fire of the enemy. The same rule holds good in the navy.

THE NAVY.

The blue line drawn round the coasts of the various quarters of the globe indicates the several commands, or stations of the British navy. The *Home station* embraces the flag-ships, revenue-cutters, &c., on the shores and in the harbours of Great Britain and Ireland. The *Mediterranean command* comprises the whole of the Mediterranean Sea, from the Strait of Gibraltar to the Gulf of Scanderoon, and the shores of Spain and Portugal north to Lisbon. The *Cape of Good Hope command* includes the east and west coasts of Africa; and the *East India command* extends from the Isthmus of Suez to Tasmania; but the operations of the squadron are principally directed to the Bay of Bengal, the coast of Coromandel, and the Island of Ceylon. The *North American* and *West Indian command* extends from the southernmost shores of the Spanish Main to Labrador, including the Windward and Leeward Islands and the whole coast of the Spanish Main. The *South American command* comprises the east and west coasts of South America, and the western shores of North America, with an occasional extension to the Sandwich, Marquesas, Society, and Friendly Islands.[5]

The diseases incident to sailors are the same as those which prevail in the countries off which they are cruising. Thus, on the North American and West Indian station, and in the West African command, the rate of mortality from fevers and dysentery is comparatively high; while off the south-east coast of Africa, the whole of South America south of the equator, and the northern shores of North America, which are all very healthy, it is remarkably low. The comparative amount of sickness and mortality from consumption is shown in the following Table, which gives the average for seven years, from 1829 to 1836:—

STATIONS.	Number attacked per 1000 of force.	Died per 1000 of force.
East Indies,	2.9	1.2
Home,	4.1	1.4
South America,	3.2	1.5
Africa,	3.4	1.5
North America and West Indies,	4.8	1.9
Mediterranean,	5.1	1.9

From this it appears that the mortality from this disease was least in the East Indian, and greatest in the West Indian and North American force; but the loss in the greatest, being under 2 per 1000 annually of those employed, is not heavy when compared with that of other portions of society at corresponding ages. Although the proportion of mortality in the West Indian and North American and the Mediterranean commands was the same, the proportion of attacks in the latter preponderated. From the returns it appears that the Mediterranean station of cruising-ground is the least favourable of any to consumptive disease; for, besides the greater frequency, there was also a larger proportion of invaliding. The East Indies was most favourable for diseases of the lungs, but least so for dysentery. On the Home station the deaths from this cause amounted to only 3 in 56 attacks; in the East Indies the ratio was 4.2 per 1000 annually; in the African, 3.4; in the South American, 1 per 1000 annually of force; and in the West Indian and North American commands, and the Mediterranean, it was 1 in 3500 each.[6]

Nothing can be more striking or satisfactory than the results of sanitary measures in the British navy. Formerly scurvy, putrid fevers, and ulcers, were considered inseparable from a life at sea. In 1741, the Centurion ship of war lost 200 men out of 400 from scurvy, on the South American station, which is now as healthy as the Home station. In 1797 the victualling of the navy was changed. Abundance of wholesome food and good water was supplied, and immediately the health of seamen strikingly improved, and this improvement has been regularly progressive. In 1779, one out of every 8 seamen employed in the navy died; in 1811, one out of 32; in 1836, one out of every 72. Or in other words, 76 years ago the mortality was at the rate of 125 per 1000 annually of the force employed; 50 years ago, 31; 15 years ago, 13 per 1000; and now (1856) the lifetime of sailors is not only far beyond that of soldiers, but the chances of longevity in a well-regulated life at sea are at least equal to those in the most favoured regions ashore. Between the years 1780 and 1783 the comparative mortality in the British navy was, from disease, 3200 men; died in battle, 640; died by wounds, 500. During the 3 years of active hostility on the coasts of China, 1840-1843, only 29 men fell by the hand of the enemy, while 748 perished from other causes, chiefly diseases produced by climate.

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[1] From 1821 to 1827, in time of peace, the annual mortality among the French army in France amounted to 19 per 1000 men. There are no returns of the civil population in France by which to make a comparison, but during the same years the proportion among the male population of Britain, between the ages of 20 and 30, was 9.91 per 1000, or less than one-half of the former.

[2] Denkwürdigkeiten zur medicinischen Statistik von Dr Joh. Ludw. Casper. Berlin, 1846.

[3] Exactly 12.9. The average is taken from more than 14 millions of men, over a period of 8 years.

[4] Martin's British Colonies, vol. i. p. 569, 1855. The table was furnished by Colonel Tulloch.

[5] This was the arrangement of the commands from 1829 to 1836, the period to which the comparison extends; but in 1837 a division of the South American station took place, the force employed in the Pacific being placed under the command of the flag-officer whose jurisdiction had previously extended over both seas. In 1840 the Brazil command was extended eastwards to the Cape of Good Hope, and the African station was again separated from the Brazilian.

[6] Return of the Health of the Navy, 1841, part 11, p. 208. *Diarrhœa* showed at sea the same proportionate increase with heat as on land, for while in the Home station the proportion was 51.4 per 1000 annually of the employed, in the Mediterranean it was 78.1; in the South American, 80.6; in the African, 83.8; in the East Indian, 101; and in the West Indian and North American, 120 per 1000 annually of the employed. *Catarrhal* cases, on the contrary, showed a decrease with increasing temperature; thus—Home station, 233.1—Mediterranean, 201.7—West Indian and North American, 181.8—African, 180.7—East Indian, 174—South American, 139.8 per 1000 annually of the force employed; while the *rheumatic* cases show how little this disease is dependent on low and varying degrees of temperature. On the Home station the ratio is 79.3—African, 78.6—South American, 72.3—West Indian, 69—East Indian, 65.3—Mediterranean, 68.9. Thus, in the East Indies, where the temperature is uniformly high, the proportion of rheumatism is greater than in the Mediterranean, where transitions are frequent, rapid, and often great. (See Diagram at foot of Plate.)

DIAGRAMS EXHIBITING THE COMPARATIVE ANNUAL MORTALITY IN DIFFERENT COUNTRIES.

THE probable lifetime of an individual at a certain age is equal to the number of years which must elapse till the whole number at that age be reduced to one-half. Of 1000 lives of equal goodness, any one may expect to live as long as he has an equal chance of living,—that is, till 500 are extinct. Or if, in a given population, 10 persons were to die out of every 1000, the average duration of life would be 50 years; at the end of 90 years there would be 100 of the 1000 living, and of that number 10 would survive to complete the century.

The average duration of human life is nearly the same among the different races of men, but the proportional number of individuals who attain a given age differs in different countries;[1] the warmer and more moist the climate, other things being equal, so much the shorter is the mean duration of human life.

The actual amount of mortality is, in every country, far beyond that which is inevitable. Even in England it is shown, on good authority, that the inevitable mortality is under one-half of that which is recorded.[2] From the Census of 1851 it appears that the average duration of life among the Society of Friends is 51 years, 2 months, and 21 days, the mortality being equivalent to 9.76 per 1000 annually; while the deaths over the whole population of England and Wales is 21 in 1000, or more than double this amount. Eminent statisticians have laboured to ascertain the comparative rate of mortality in different countries; but as this is a question depending on exact returns of births and deaths, little more than an approximation can be expected from existing materials. The Diagrams Nos. 4 and 5 at the foot of the Plate present an abstract of the mortality of those places which are best ascertained, extracted from an extensive series of MS. tables arranged by Dr Stark of Edinburgh.

Diagram No. 1 shows the proportion of deaths from consumption, from the returns of the British army; and No. 2 exhibits the proportion of attacks of rheumatism among the troops in different quarters of the globe. No. 3 shows the comparative value of life in different countries, the population being taken indiscriminately, without regard to age at death—the upper portion referring to countries, and the lower to cities. These comparisons are deduced from the census returns of the births, marriages, and deaths of each place, and give the nearest approximation possible. But it is important to bear in mind, that in estimating the effect of climate on mortality, allowance must be made for newly-settled countries—as the interior states of North America, Canada, Australia, &c., where the population being mostly in the prime of life, the rate of mortality is necessarily much lower than in the older countries. No. 4 shows the proportionate mortality of European residents in foreign countries.

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[1] In England this difference varies from 25 years in Liverpool and Manchester to 45 years in Surrey, and in other localities to a number of years still higher; and in Scotland the proportion of deaths in 10,000 living was in some of the rural districts so low as 149, while in Lanarkshire it was 269, or nearly double the amount.—See the valuable Statistical Returns of Births, Deaths, &c., of Scotland for 1855, and Census Reports for 1851.

[2] Mr William Lee, in his "Summary of Experience on Disease," London, 1851, states, that in this country the deduction of the deaths arising from preventible diseases from the whole deaths leaves an inevitable mortality of only 11 to 1000, or 110 in 10,000, and that this is nearly a constant quantity in healthy and unhealthy districts.

For the ten years ending 1846, from the table above, with additions from previous returns.

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